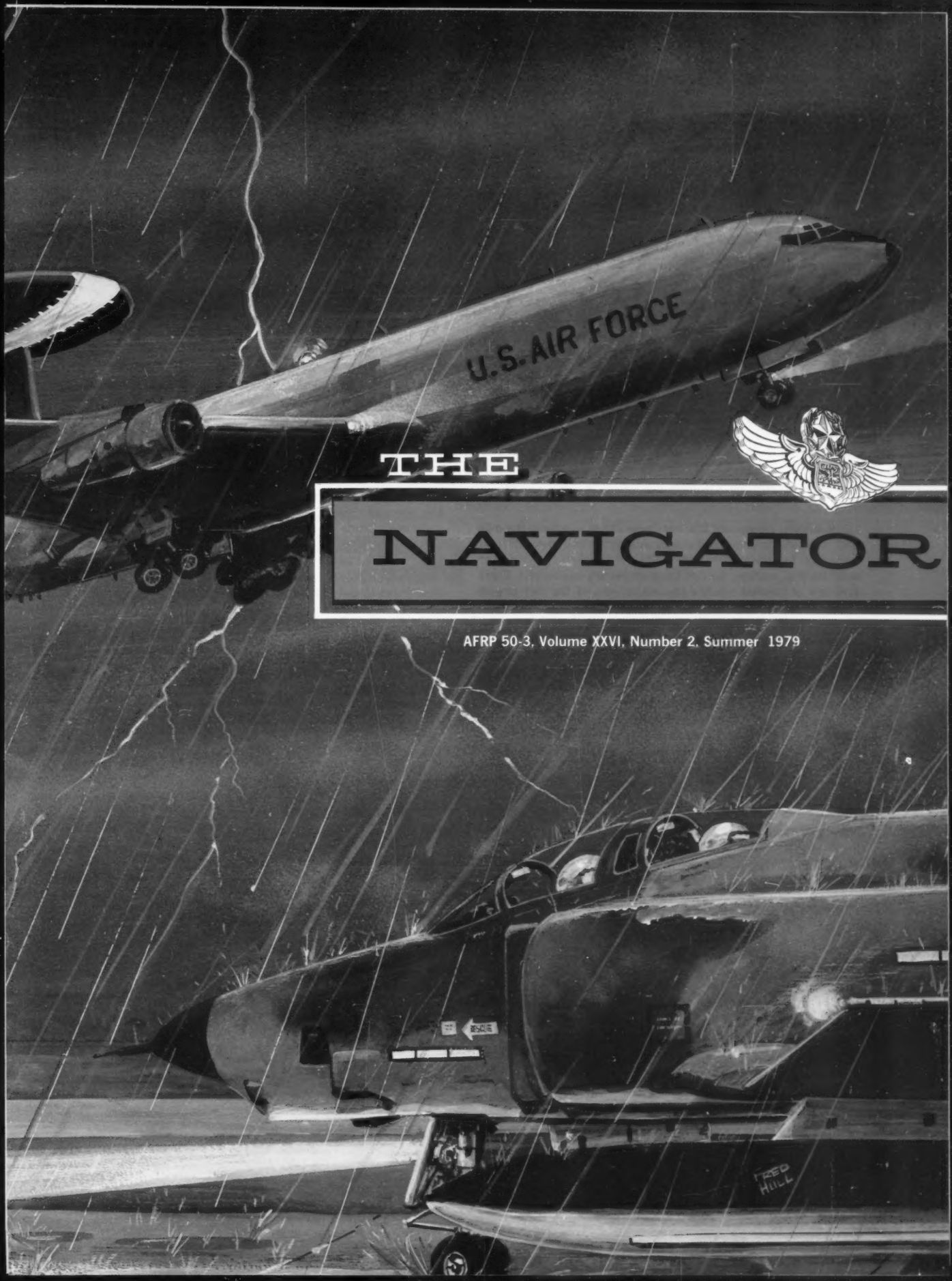

THE NAVIGATOR

AFRP 50-3, Volume XXVI, Number 2, Summer 1979

Among the many "Navs of Note" we have received, Lt Col Conal J. Brady and Major John R. Pond are excellent examples of navigators holding leadership positions in operational units. Since navigator command of flying units is of utmost importance to us, we have chosen these gentlemen as our Navs of Note.

NAVS OF NOTE

Recently, Lieutenant Colonel Conal Brady has been the only SAC navigator in command of a tactical flying unit, the 916th Air Refueling Squadron, Travis AFB. One of the first navigators to hold such a position, he has been eminently successful. Every function of Colonel Brady's command, one of the two largest tactical squadrons in the Strategic Air Command, has been rated no less than excellent during his two-year tenure.

Colonel Brady began his flying career as one of the original "Guys in Back" prior to the F-4 GIBs of the current era. He spent a brief period in Air Defense Command F-89Js before his unit transitioned into the F-101B Voodoo. After 1000 hours in the Voodoo, his unit, the 49th Fighter Interceptor Squadron, was again re-equipped; this time with the F-106. Colonel Brady was the unit Executive Officer and remained for some months getting his intercept requirements in the two-seat F-106B. With the increased activity in Southeast Asia, Colonel Brady returned to a primary cockpit job as a KC-135 navigator with the 41st Air Refueling Squadron at Griffiss AFB, NY.

"I recall at the time that I was not too happy getting a large aircraft since I had really enjoyed fighters. I went to Combat Crew Training at Castle AFB where I actually had to learn to navigate again, particularly in the area of celestial. Although I didn't recognize it at the time, my reassignment to SAC was the best thing that could have happened to me. I took the positive approach and found that I enjoyed the new aircraft and the new mission."

After four and one-half years of SAC combat crew duty, Colonel Brady was reassigned to the 95th Strategic Wing, Goose Bay, Labrador, where he served as Chief of EWO Operations, Chief of the Current Operations Division, and Chief of Operations and Training. On his return from overseas, he was assigned to the 307th Air Refueling Group at Travis AFB.

"Since I have been in the Strategic Air Command, additional responsibility has followed every successful accomplishment. Patience, a positive outlook, and personal endurance have been necessary—and rightly so. I hope we still allow our younger people the opportunity to develop the personal discipline called patience or, more specifically, protracted effort in the face of frustration. Impatience in a self-actualizing individual is a reflection of personal drive, so it is not necessarily a negative characteristic. A lack of perspective or failure to develop the ability to recognize and control personal frustration can subvert the personal drive."

Colonel Brady is a master navigator and his decorations include the Meritorious Service Medal, Air Medal, Air Force Commendation Medal with three oak leaf clusters, the Outstanding Unit Award with V device, and the Combat Readiness Medal with three oak leaf clusters. In addition to his military awards, Colonel Brady is an accomplished scholar. He led his graduate school class at the University of Southern California with a 4.0 GPA and subsequently was elected to membership in the Phi Kappa Phi national honor society. In addition, he has received a special presentation of the Strategic Air Command Outstanding Education Award and the Distinguished Education Award.

"The last 22 months have convinced me that tactical flying is definitely the training ground for Air Force leaders. One of the primary responsibilities of command is training the troops, but, in a very real sense, the troops also train the commander. The experience and knowledge I have gained have been truly invaluable. I can't conceive of any other way to acquire it, and I will be forever grateful for the opportunity."

As this issue goes to press, Colonel Brady is arriving at his new assignment as Commander of Detachment 1, 19th Air Division, and Senior Advisor to the Tennessee Air National Guard at McGhee Tyson ANG Base.

NAVS OF NOTE

Major Pond (a lieutenant colonel selectee) is Operations Officer, 340th Bomb Squadron, 97th Bomb Wing, Blytheville AFB, Arkansas.

A native of Medford, Oregon, Major Pond graduated from the University of Oregon in 1963. He entered the Air Force in September of that year through Officer Training School. His first assignment was as a deputy missile combat crew commander in the Atlas E at Forbes AFB, Kansas. In March 1965, he was

transferred to Grand Forks AFB, North Dakota. There he served on an instructor crew in the newly activated 321st Strategic Missile Wing and helped build the upgrade and recurring training programs for the latest SAC weapon system, the Minuteman II. While at Grand Forks he was ordered to UNT. He arrived at Mather in April 1967.

Major Pond received his wings in December of that year having been designated a Distinguished Graduate and winner of the Husak Memorial Flying Trophy and the Daughters of American Colonists Award. He chose NBT and the subsequent B-52G assignment to Loring AFB, Maine. His four years at Loring included three Arc Light/Bullet Shot tours and 103 combat missions over Southeast Asia. Also during that period, he flew in the 1970 SAC Aircraft Combat Competition and was among the first crew radar navigators in SAC to become qualified in the SRAM.

In August 1972, Major Pond attended AFIT to prepare for duty at the Air Force Academy as an astronomy and navigation instructor. He served as Course Director, Planetarium Director, and Chief of the Science Astronomy Branch and in 1976, was awarded the academic rank of Assistant Professor (the first member of the staff of the Commandant of Cadets to be so named.)

Throughout this period, Major Pond remained active in flying. He was an instructor navigator for cadet missions in the T-29 from 1973 to 1975. As a supervisor of division flying for the newly designated Aviation Science Division, he played a major planning and operational role in the transition to the T-43 in 1975. About his Academy tour Major Pond said, "It was a most rewarding experience, invaluable in learning to understand our next generation of officers."

Major Pond left the Academy in January 1978, to attend the Armed Forces Staff College in Norfolk, Virginia. Returning to SAC in September, he reported to Blytheville AFB, Arkansas, and requalified as a B-52 radar navigator. He became Operations Officer of the 340th Bomb Squadron in November. "Being the Ops Officer of a Bomb Squadron offers a wide range of challenges that derive from a wide range of people and problems. I can think of no better preparation for command." When asked about being a navigator operations officer he said, "SAC navigators and EWOs are exceptionally well prepared for leadership positions. The responsibility for successful bombing and ECM rests squarely on our shoulders. However, decision-making experience must not end with in-flight duties. We must not accept any implied limitations on our ambitions or abilities."

FROM THE EDITOR

Thanks to our many readers who took the time to complete the Reader Survey in the last issue. You asked us to get more WSO, EWO and career articles—we will. Another frequent request we're working on is for more material about the navigator's role in the Air Force Reserve and the Air National Guard. Besides those main categories, the suggestions included many good story ideas that we can pursue.

Because of those ideas, and extraordinary cooperation from various Air Force offices, we are able to contemplate themes for future issues. These include energy conservation in flight operations; Electronic Warfare; and the Weapon Systems Officer of the future. We are particularly interested in these subjects as well as your inputs to new features on navigational "war stories" and navigating the old classics (wouldn't you older-young guys like to tell the younger-young navigators about the B-47, B-58, KC-50, C-124, F-89, etc?) We have been receiving many excellent articles and the above suggestions are meant only to give direction to those additional contributors waiting with pens at the ready.

Finally, it is a great pleasure to introduce your new editor. With the next issue Captain Richard E. Garr, Jr. will assume responsibility for THE NAVIGATOR magazine. With wide experience, including 5½ years of F-4 operational flying, Captain Garr has both the background and talent to manage our magazine. I know he will enjoy your continued support of THE NAVIGATOR.

TO THE EDITOR

Dear Editor

Major Ravenel's article on The Plastic Overlay Trick was interesting; however, I find an additional technique to be useful. I draw the orbit area (CP to IP) with a grease pencil or visual aid pen. This may be done during mission planning and provides several advantages. First, the nav can run the rendezvous on the overlay, without the possibility of confusing the lines on the overlay with the lines on the chart. Secondly, this eliminates the need to tack, tape, staple, or hold the overlay immovable over the station.

Another use for the overlay is to quickly check the copilot's TACAN fixes. And we may use them once in a while when we navigate to and from VORs or TACANs.

James S. Leland, Captain, USAF
305 AREFW, Grissom AFB, IN

Department of the Air Force

THE NAVIGATOR

AFRP 50-3, Volume XXVI, Number 2, Summer 1979

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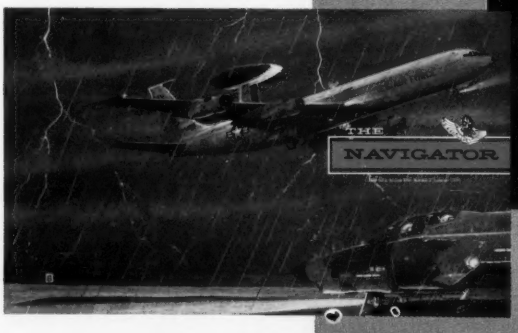


Our theme—weather—is strongly in evidence as an E3-A Sentry lifts off while an RF-4C taxies down the parallel. "Weather and War," page 5, brings a historical view to this subject of great interest. For an interesting perspective on the navigator career, see "Half A Chance," page 24.

Distribution: One copy per two navigators.

Weather and War

Mr John F. FULLER
HQ MAC/HO
Scott AFB, IL

"Weather is the essence of successful air operations."

H. H. Arnold, *Global Mission*

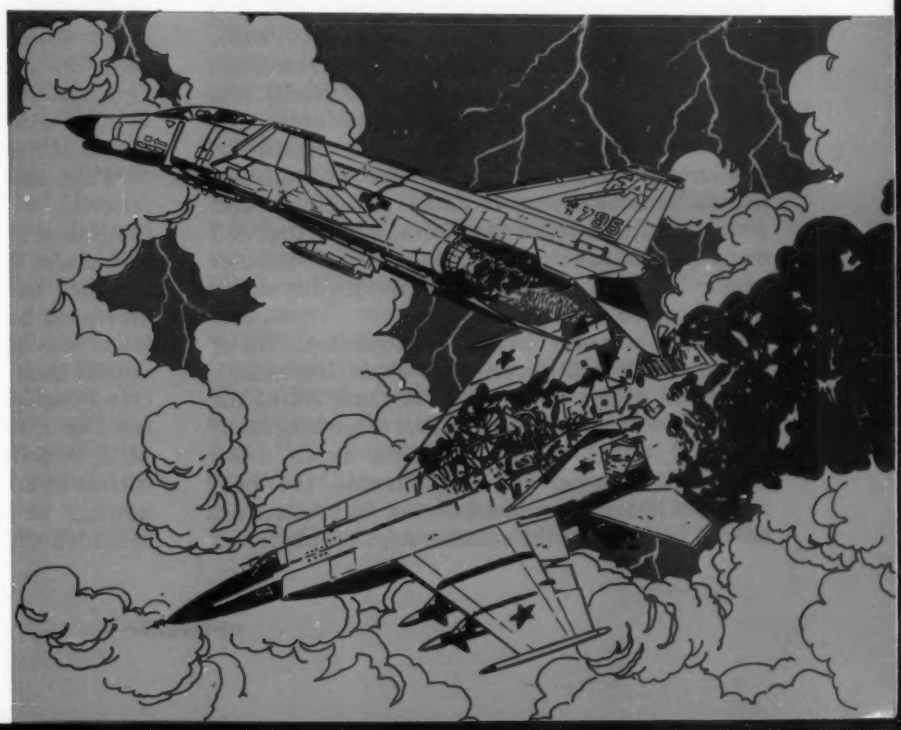
History's scrolls are replete with entries chronicling weather's effects on its navies, armies, and air forces in wars from before Christ to Southeast Asia. Herodotus wrote that in the 5th century B.C., Xerxes lost nearly half his fighting strength when severe storms shattered his plans for invading Greece by inflicting great damage on his Persian fleet off the Magnesian Peninsula. It was a *Kamikaze*, a divine wind, of 1281 that fanned the storms and wrecked most of the fleets to break the back of the second Mongol invasion of Japan. In 1588, after his Spanish Armada had been defeated by the elements as much or more than by the English Navy, Spain's King Philip II reportedly said, "I sent them to fight the English, not storms."

Some of Clio's armies fared little better. Sweden's Charles XII suffered a defeat at Poltava after the particularly fierce Russian winter of 1708-1709 extracted a lethal toll in exhaustion and hunger from his invading army. Although he had studied Charles XII's experiences, a similar fate befell Napoleon a century later. "The cause of the destruction of the French army in 1812 is clear to us now." Leo Tolstoy wrote in his epic saga, *War and Peace:* "its advance into the heart of Russia late in the season without any preparation for a winter campaign, and...the burning of Russian towns and the hatred of the foe this aroused among the Russian people."

Weather played a key role also in Napoleon's most famous date with destiny. Rains forced him to delay a day, until the ground dried, his pursuit of Wellington, who took up a defense south of Waterloo. It was a fatal delay for Napoleon's ambitions. "Had it not rained on the night of the 17th of June, 1815," penned Victor Hugo in his classic *Les Miserables*, while bemoaning Napoleon's lot, "the future of Europe would have been changed. A few drops of water more or less prostrated Napoleon. That Waterloo should be the end of Austerlitz, Providence needed only a little rain, and an unseasonable cloud crossing the sky sufficed for the overthrow of a world."

And it was Napoleon who allegedly said that "the military strategist who leaves weather calculations out of his plans can never be a marshal in the armies of France."

In the war President Wilson hoped would make the world "safe for democracy," allied aviators found the prevailing westerlies one of their biggest concerns. They speeded flights eastward, but severely hindered the slow-flying aircraft's



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return. At somewhat higher altitudes in World War II, aviators encountered equally perplexing winds, the jet streams.

When Adolf Hitler invaded Poland in September 1939, his forces enjoyed unusually dry and favorable weather for *blitzkrieg* tactics—weather that had been accurately forecast by German meteorologists. From 1935 on, in the case of the *Luftwaffe*, the weathermen were present at every orientation session, every conference in which combat orders were issued, and at every situation briefing. Their tactical weather charts rested on the planning tables beside the strategic situation maps.

Undue liberty would not be taken with history by suggesting that in the planning and execution of every major compaign by all of the combatants during the WW II, be it on land, sea, or in the air, weather considerations and weather played a role—sometimes one of the utmost criticality. Each engagement could have been recorded in terms of the movement of air masses, frontal passages, phases of the moon, and the way of the world's tides.

Before Germany's western offensive opened in May 1940, for example, it had been postponed some 16 times primarily because of Hitler's injunction that it be made in favorable flying weather. His eastern offensive a year later was delayed by a late spring thaw in Russia and, after spectacular initial successes, his armies ground to a halt in the shadow of Moscow's gates as the weather inevitably turned and blunted *blitzkrieg* tactics.

Field Marshal Rommel used sand storms to screen his movements from the British in Libyan Desert fighting. "The selection of the actual day would depend upon weather forecasts," wrote General Eisenhower referring to the most famous forecast ever issued, the D-Day forecast. As Churchill wired Stalin on the invasion's eve, "the difficulties of getting proper weather conditions are very great, especially as we have to consider the fullest employment of the air, naval, and ground forces in relation to tides, waves, fog, and cloud." The relatively good invasion weather encountered was essentially as predicted by Eisenhower's weathermen.

Finally, among other prerequisites, Hitler stipulated that the initial phase of Germany's Ardennes offensive be shielded from Allied air power by a period of bad weather extending for at least 10 days. During the first seven days, inclement weather critically limited the help rendered friendly ground forces by Allied air power. "As long as the weather kept our planes on the ground it would be an ally of the enemy worth many additional divisions," Eisenhower wrote. When it broke for five days beginning on 23 December 1944, providing superb flying weather, Allied air power helped smash the German offensive. "Weather is a weapon the German army used with success, especially in the Ardennes offensive," said Generalfeldmarschall Gerd von Rundstedt following his capture; "this Battle of the Bulge, as you call it, might have changed the entire course of the war, had it not been for the fact that the United States [Army] Air Force so quickly took advantage of the break in the weather."

It was the United States Army Air Forces' position that weather, while it affected a variety of military operations, "had its greatest continuing importance for air operations." Ernie Pyle recorded that "the weather was the fliers' biggest complaint," and Eisenhower wrote that "in Europe bad weather was the worst enemy of the air." AAF leaders found that European weather conditions, as official accounts relate, "were to provide one of the greatest obstacles to daylight precision bombing."

Weather factors played a similar role in the Pacific. The Japanese took advantage of an extensive storm zone to conceal their aircraft carriers' approach to Pearl Harbor in December 1941. Some 15 months later, a miscalculation in the Bismarck Sea cost them dearly when a storm, under whose canopy their convoy sought to reinforce New Guinea, dissipated and the Fifth Air Force won a major victory. And when Admiral Halsey's Third Fleet was caught in a December 1944 typhoon that capsized three destroyers, destroyed 146 aircraft (some swept off flight decks into the sea), and took the lives of some 790 men, Admiral Nimitz described it as the "greatest loss that we have taken in the Pacific without compensatory return since the First Battle of Savo [Island]."

"That element," an AAF history related in referring to weather, proved to be "the worst hindrance to the B-29 campaign against Japan." The severe frontal conditions often lying enroute to the target increased fuel consumption, decreased bomb loads, scattered formations, and made navigation so difficult that many crews missed their landfall completely. Over the target, crews seldom found atmospheric conditions suitable for precision bombing. With the high wind velocities at altitude, drift was difficult to correct and bomb runs had to be charted directly upwind or downwind. Bombing Japan's best defended cities directly in the teeth of 200-knot

winds was unthinkable; going downwind the B-29s reached ground speeds in excess of 500 mph, in which case neither bombsights nor bombardiers could function properly. Additionally, the high winds made it impossible for crews to make a second pass if the run-in failed; if a navigational error brought a plane in downwind from the target, it might be unable to attack at all.

General LeMay helped usher in the age of atomic warfare at Hiroshima on 6 August 1945—one of the most significant dates in history and a date determined by the General based on target weather forecasts. In a War Department letter dated 25 July, General Spaatz was directed to drop the "first special bomb as soon as weather will permit after about 3 August 1945." Weather was the critical factor because with only two bombs available, the drop had to be made by visual means, and Spaatz delegated to LeMay the job of deciding when weather would permit the war's most important mission. When the *Enola Gay* broke ground from Tinian on 6 August, the pilot was under instructions to select the target based on reports from the three weather planes preceding him over the primary, secondary, and tertiary targets, but to return with the bomb if all three were covered by clouds. When he got a favorable weather report, it sealed the city's doom.

Less than five years later, North Korea invaded its neighbor to the south on a morning when scattered but heavy rains fell along the 38th Parallel. Such weather conditions were to be anticipated in the upcoming weeks because the summer monsoon had just begun. Documents captured later revealed that it was not by accident that the North Koreans struck with the monsoon's onset. From their initial thrust, they habitually timed ground assaults to coincide with periods of poor flying weather because the United Nations Command enjoyed air superiority. There was also reason to believe that the Chinese Communists, knowing that the United Nations air forces would destroy most North Korean bridges, waited until the inland waterways froze before launching their attack in late November 1950.

"Korean operations demonstrated...that the USAF had not become an all-weather air force," noted the Air Force's account of that war. So-called "all-weather" squadrons simply could not operate in all manner of weather, in particular with low ceilings and limited visibilities. "Although the importance of weather in military operations had been increasingly played down as the all-weather potentialities of the armed services have been emphasized," the 1952 Air Force account read, "weather remained a major factor in planning and operations in Korea." Cloudiness over targets caused more photo-recce mission aborts than any other single factor.

The Korean experiences were repeated in Southeast Asia where weather was the single most important factor which determined whether an aerial reconnaissance mission could be accomplished successfully, and there were no such things as "all-weather" sensors for such purposes.

The monsoon humidity and salt air in Southeast Asia speeded mildew, rust, and corrosion and levied a toll upon sophisticated Air Force gear. The average life-expectancy of anti-G suits was one year. In Southeast Asia, it was nine months. The heat and humidity caused canopy fogging problems for the F-5s at low altitudes, and it caused the sealant of the shelters they and other aircraft were parked in to fail. It lengthened take-off rolls and reduced payloads. For a period it grounded the F-4s when it melted an inferior potting compound used to insulate electrical connections. Monsoon rains accentuated the F-4s bad habit of hydroplaning on wet runways and quickly washed away subsoils beneath aluminum runway matting.

Weather tempered the targeting, tactics, timing, and type of ordnance employed by the Air Force in Southeast Asia. Referring to the air campaign against North Vietnam during early 1966, Admiral U. S. G. Sharp reported that weather "caused a high percentage of cancellations or diversions and greatly limited the information obtained from bomb damage assessment." "Weather is often a limiting factor in planned operations," a Senate report issued the following year read while addressing that campaign. As if to substantiate the report, Secretary McNamara testified before the House in February 1967 that "at the present time the level of activity [against North Vietnam] is limited not by aircraft but by weather." The fact that Seventh Air Force's two major omnibus air plans were entitled "Northeast Monsoon Campaign" and "Southwest Monsoon Campaign" underscored the respect paid to weather's influence on the air war, and the fragmentary orders issued in their names were often laced with the enjoinder, "weather permitting." In testimony before Congress in April 1968, Secretary Clifford said, "I have grave doubt that the state of the art has reached that point where we can bomb in all kinds of weather with the kind of accuracy that is required." And

the so-called "smart" bombs—electro-optical, laser, or infrared guided ordnance—were "smart" only when launched in the absence of weather.

From Thud pilots over Hanoi through the highest levels in the Pentagon to the President, Southeast Asian weather was a factor frustrating their plans. It was true from the Gulf of Tonkin until the cessation of hostilities, for air and ground campaigns. On 7 February 1965, in the wake of the Viet Cong attack at Pleiku, President Johnson authorized retaliatory air strikes against targets in North Vietnam but "three of the four authorized targets had been fogged in," he wrote later; "only one had been struck."

During the North Vietnamese Tet offensive of early 1968 and the highly-publicized siege of Khe Sanh, weather was "another critical factor [that] had to be considered," reported General Westmoreland; "we were in the midst of the northeast monsoon with no prospect of relief from bad weather until the end of March," he continued, and the "poor visibility...because of low clouds and persistent ground fog made helicopter movement hazardous if not impossible much of the time," and "posed major problems for close air support and supply by air." Referring to the February battle of Hue, General Cushman, the commander of the III Marine Amphibious Force, estimated that "with a break in the weather the [26-day] battle would have been fought and won in half the time." During any one day, the best weather at Khe Sanh lasted only six hours during which clouds were in a scattered-to-broken condition between 1,000 and 2,500 feet with visibility never much more than five miles. In the early morning, afternoons, and late evening, weather reduced visibility to less than a mile. The JCS chairman admitted to a Congressional committee that Westmoreland had a "weather problem," and General McConnell testified that "we are supporting Khe Sanh by airdrop, because the weather is so bad you cannot land."

In early May 1970, after being summoned before Congress regarding the United States "intrusion" into Cambodia a few days earlier, Secretary Laird testified that the invasion's timing was predicted on two factors primarily: politics—a new Cambodian regime—and the weather. "I am sure that the motivation of the President," he said, "was to take advantage of this 3-6 week period [of good weather] while we have an opportunity to destroy these [North Vietnamese] sanctuary facilities and enable us to protect American lives in Vietnam in the future."

Beginning on Sunday, 26 December 1971, following the traditional Christmas ceasefire, President Nixon authorized five straight days of the most sustained air attacks against North Vietnam since the 1968 moratorium. Asked by Congress to comment on the validity of press reports that the air strikes, conducted under the code name "Proud Deep Alpha," were something less than an unqualified success, General Ryan admitted that "it was bad weather during all five days in which we were bombing by instruments, and we could have accomplished more had it been clear weather."

"On the 30th of March 1972," commented Admiral Moorer, "under the cover of very low ceilings and low visibility, the North Vietnamese, for the first time in this war, moved a complete division" across the DMZ in launching a large offensive against South Vietnam. It was 20 April and the JCS chairman had been called before Congress to explain why the invasion had proceeded virtually unchecked. He prefaced his entire testimony with a detailed weather synopsis, explaining to the solons that "weather programs play a greater part with respect to the military activities in South Vietnam than in any other part of the world," that the transition between monsoons had produced low clouds, fog, and poor visibility near the DMZ worse than normal for the season, and that "it was under these conditions they were able to operate without much air opposition for a rather long period." With the aid of radar, the B-52s were used, but during the first 12 days of the invasion there was only one day during which tactical aircraft were able to effectively attack the fleeting targets.

Nine months later Admiral Moorer was again summoned to brief Congress on the resumption of the bombing of North Vietnam by the United States north of the 20th Parallel in operations

code named "Linebacker II." "As it turned out," he testified while commenting on weather's effects, "during the period that we were conducting the operations, which lasted from December 18 to 29, with the exception of a 36-hour stand-down for Christmas, there were actually only about 12 hours which were suitable for visual bombing, including use of the so-called 'smart' bombs."

Thus it is, as General Eisenhower once poignantly noted, that weather has never been neutral in war; the advantage in battle often fell to the side which carefully took it into consideration beforehand. Those who ignored it succumbed. With advances in weapons technology, many came to believe that the weather factors had been "engineered" out. History shows otherwise. Severe storms at sea sent Persian galleys and the Spanish Armada's galleons to Davy Jones' locker, as well as the modern destroyers of Admiral Halsey's Third Fleet. World War II aircraft flew higher, faster, and farther than those of World War I. Yet the jet stream encountered over Europe sometimes slowed B-17 ground speeds to less than those of the Lafayette Escadrille's open-cockpit Nieuports a quarter century earlier. During Korea and Southeast Asia, with the aid of their weathermen, aviators learned to use those winds to advantage. When Southeast Asia conclusively demonstrated again that the Air Force had come up measurably short of its all-weather goal, technicians turned to "smart" bombs to make its aircraft all-weather. They, too, were not all-weather weapons systems. In fact, a literally all-weather military force neither exists nor is on the horizon. New weapons systems sire new weather problems and they become more weather sensitive, not less. Military meterologists help negate or minimize the weather problems. Their services are worth too much for today's commanders to ignore.

Mr Fuller, a graduate of the University of Nebraska (Omaha), has a master's degree in History from the University of North Dakota. He served in the Air Force from 1958 to 1965 and flew the F-101B. Mr Fuller presently is the historian for the Air Weather Service, HQ MAC, Scott AFB.

Air Weather Service

HQ MAC/OI
Scott AFB, IL

As a MAC technical service, USAF Air Weather Service operates a worldwide network of weather facilities to provide continuous weather support to US Air Force and Army units. AWS Headquarters, at Scott AFB, IL, directs operations of six weather wings with 15 weather squadrons and coordinates requirements for worldwide aerial reconnaissance with the Aerospace Rescue and Recovery Service. More than 4,500 officers, airmen and civilians operate a global weather forecast central, an environmental applications center, and some 270 detachments and operating locations. Nearly one-third of these units are located overseas.

Weather forecasting requires masses of accurate and timely raw data. Faced with providing weather support on a global basis, AWS has the basic task of collecting worldwide weather observations. AWS units gather data at most Air Force and Army installations in North

America, Europe, Africa, Asia, and the Arctic, on Pacific Islands, and at other places where the weather affects US military operations.

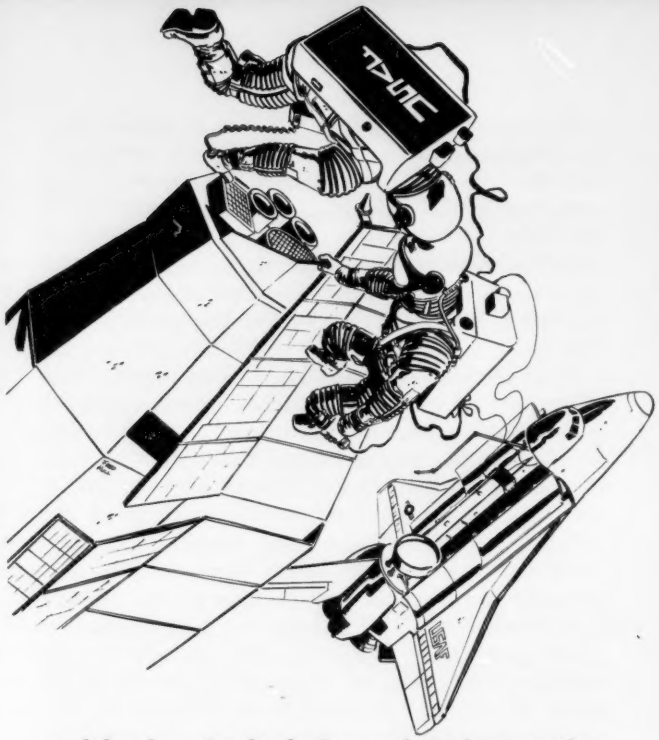
Air Weather Service people observe and report critical weather data from oceanic areas while flying in WC 130B/E/H Hercules aircraft operated by the Aerospace Rescue and Recovery Service. Weather crews based in Keesler AFB, MS, and Andersen AFB, Guam, fly into hurricanes and typhoons, penetrating the "eye" to obtain its position and meteorological pulse. Their reports from the center of these tropical storms enable the National Hurricane Center and the US Navy/US Air Force Joint Typhoon Warning Center to more accurately forecast the velocity and the intensity of these devastating storms in an effort to save lives and property.

The United States is represented on various commissions of the World Meteorological Organization and other international organizations which maintain a free flow of weather data from nation to nation and continent to continent. This exchange of information helps AWS fulfill its far reaching mission. The USAF Automated Weather Network provides the communications to collect and disseminate weather information to the many AWS customers in a timely manner.

To provide responsive mission-tailored support on a global basis, AWS must rely upon computer technology. The Air Force Global Weather Central located at Offutt AFB, NE, uses one of the world's largest computer complexes devoted entirely to environmental support. Here, weather information from all parts of the world, including information gathered by the Defense Meteorological Satellite Program, is received, processed, and analyzed. From these analyses comes a wide variety of tailored forecasts to meet the operational needs of our military forces.

Air Weather Service responsibility does not end with forecasts to the Air Force and Army. A weather service which looks to the future must provide for use of historical data and analyses through applied climatology. The mass of data accumulated daily at Global Weather Central is retained as a working file at the USAF Environmental Technical Applications Center, Scott AFB, IL, and an operating location at Asheville, NC. At these two locations AWS climatologists support operational and logistical planning, weapon system acquisition, and other specialized Department of Defense activities requiring climatological support.

AWS people actively participate on numerous national and international committees which plan



and develop standards for exchanging weather data and coordinate peacetime and contingency support procedures. These cooperative ventures assist in developing weather support to the fighting forces of the free world.

As new weapons and vehicles of the space age are developed, AWS requires more accurate knowledge of conditions in the earth's atmosphere and beyond to support them. To meet the demands for environmental support to space-oriented systems, AWS operates the Space Environmental Support System. The system is a worldwide network of solar observing sites made up of optical telescopes, radio telescopes, and various other sensors to monitor the sun and near-earth space environment. The observed data are transmitted to Global Weather Central where they are analyzed and specific forecasts of space environmental effects made for the varied space systems.

Presently, AFSC is developing the Modular Automated Weather System. This is a system of sensing devices coupled with a micro computer which will automatically sense and record weather data and generate short-range forecasts. Although the system is still in the development stages, it demonstrates that electronic technology can be exploited to improve weather support while expending fewer resources.

Today's Air Weather Service plays a unique and vital role in Air Force and Army operations worldwide. It is a valuable national resource keeping step with the meteorological and environmental needs of the space age.

Weather Penetration or Weather Avoidance ?

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Engineering Experiment Station
Georgia Institute of Technology
Atlanta, GA

All-weather capability is a necessary goal for military aviation and is advantageous for non-military aviation as well. While improved instrumentation and communications permit operations in many low-ceiling and low-visibility conditions, certain meteorological conditions remain inherently hazardous to flight. These include turbulence, wind shear, icing, hail, and lightning. Turbulence and wind shear may occur in the clear atmosphere, either in the low-level boundary layer or near upper-level jet streams, and icing may be encountered in stratiform clouds. But all of these hazardous conditions can occur in a thunderstorm. The detection and avoidance of thunderstorms and their associated hazards is therefore essential to flight safety.

Over the years, radar has been the most widely used severe storm detection device, both on the ground and in the air. While ground-based weather radars can be larger and more powerful than airborne radars, only an airborne radar can determine the detailed structure of weather in relation to an aircraft in flight. Weather radars usually sense the returned signal or echo from precipitation, i.e., from rain or hail, rather than from non-precipitating clouds. Radar echoes from ice crystals or snow are generally much weaker than echoes from rain. The relationship of radar echo strength to precipitation intensity is complicated since the echo strength is not directly proportional to the water content or rainfall rate. This relationship becomes more complicated in the presence of large hail, because the size of the objects producing the echo is an appreciable fraction of the wavelength of the radar signal. These complications are more significant at shorter radar wavelengths, where in addition to the peculiarities of signal scattering, the radar signal is partially absorbed by the precipitation. The loss of signal strength due to absorption and scattering by precipitation is called "attenuation."

These considerations might be academic but for the fact that the limits of space and weight on an aircraft virtually require that airborne radars operate at the shorter wavelengths where signal attenuation can be significant and where the scattering properties of large raindrops and hailstones are more complicated. In using an airborne radar for weather surveillance, the flight crew must be aware of its limitations, especially in the observation of severe storms. Ironically, it is in such situations that accurate depiction of the shape and intensity of echoes is most essential to flight safety.

The limitations of airborne radar for weather surveillance are illustrated dramatically and tragically by the crash of Southern Airways Flight 242 in northwest Georgia on 4 April 1977. The transcript of the cockpit voice recorder tape indicated that the flight crew, relying on their airborne weather radar, observed what they thought was a "hole" in a line of thunderstorms. The flight proceeded on a path close to the center of the storm, and the resulting ingestion of water or hail contributed to the total loss of power in both engines.

The following analysis and discussion are, of necessity, somewhat speculative since details of the configuration and operational status of the on-board radar are unknown. Also, data from the National Weather Service radar at Athens, GA, some 100 nautical miles from the storm center, provide only an approximate representation of the reflectivity structure that would have been observed from the aircraft. Nevertheless, the analysis illustrates the effect of signal attenuation in a particularly severe situation and emphasizes the need for flight crews to obtain current weather radar reports and other weather information from ground stations in such conditions.

The National Transportation Safety Board presented radar data from the National Weather Service radar at Athens, GA, in its accident report (NTSB, 1978) in the form of rainfall rate.

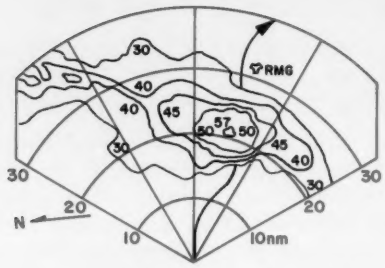

Figure 1

Display of 10-cm (S-band) reflectivity factor (10 log Z) based on NWS weather radar data. Coordinate origin is aircraft position at 1604 EST. Heavy line indicates subsequent ground track of aircraft. Rome, GA, VORTAC is shown for geographical reference.

Maximum rainfall rate was classified as "extreme," in excess of five inches per hour. These data are shown in Figure 1, reconverted to radar reflectivity factor "Z" and drawn in coordinates relative to the aircraft position about 1604 EST, when the captain and first officer were discussing the "hole" in the echo. The criterion of reflectivity in excess of 50 dBZ has been used as an indicator of hail in a storm; the presence of a large area of high reflectivity in this case, especially at such a distance from the Athens radar, indicates a very high probability that hail is present.

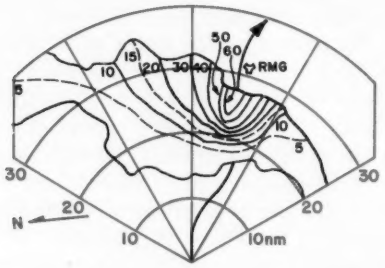

Figure 2

Total (two-way) attenuation due to the reflectivity structure shown in Fig 1. Outline of storm at 30 dBZ level is shown for comparison.

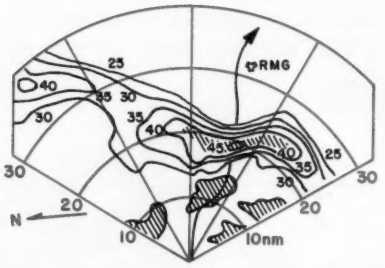

Figure 3

Display of 3-cm (X-band) reflectivity based on the data of Figs 1 and 2. Note altered shape of storm echo and maximum reflectivity above 45 dBZ close to the region of high reflectivity gradient. Area with reflectivity greater than 41 dBZ is shaded. Shaded areas at less than 16 nm range are areas of no echo, based on NWS radar data.

The rate of attenuation of the radar signal, in decibels lost per unit distance traveled, is nearly proportional to the rainfall rate. This quantity can be derived easily from the rainfall rate data presented in the NTSB report. The total attenuation of the signal depends on the total distance of its travel through precipitation as well as on the precipitation rate. The effect of attenuation on the measured radar echo is therefore cumulative with range, being very small on the near side of a storm but increasing with distance into the storm and being most severe at the far side of a core of very heavy precipitation. These characteristics are illustrated in Figure 2, which shows the total attenuation experienced by the radar signal. If the total attenuation levels are subtracted from the true reflectivity pattern shown in Figure 1, then we have the apparent reflectivity pattern, shown in Figure 3, which would have been observed by the 3-cm (X-band) airborne radar. This radar was equipped with a contouring circuit which, if working properly with a threshold level of 41 dBZ (NTSB, 1978), should have suppressed the echo within the shaded area around the storm center, about 20 nm range.

A comparison of Figures 1 and 3 reveals several noteworthy features. Because of attenuation the 3-cm reflectivity indicates a storm of less severity than was actually occurring at the time. The 3-cm reflectivity also indicates a smaller horizontal extent of the storm along the projected path of the aircraft. The point at which the aircraft penetrated the storm is the narrowest part of the strong echo. Apparently the captain referred to this feature at 1606 EST when he said, "I think we can cut across there now," as the aircraft began a slight turn to the left before entering the storm.

The cockpit voice recorder transcript noted the sounds of rain and hail between 1604:00 and 1604:30. Because the aircraft was flying in rain at this time, the total attenuation of the radar signal at 1604 could have been several dB more than that shown in Figure 2. In this case the maximum 3-cm reflectivity might not have exceeded the contour threshold. The area between the aircraft and the storm center would have been generally filled with radar echoes with possible echo-free areas, as suggested by the NWS radar data presented in the NTSB report. Moreover, since intermittent precipitation had been encountered en route and occasional echo-free areas probably appeared on the radar display, the high-reflectivity contoured area could have been misinterpreted. In any case, from the west side of the storm the eastern edge of the radar echo would have been observed distinctly as the edge of the

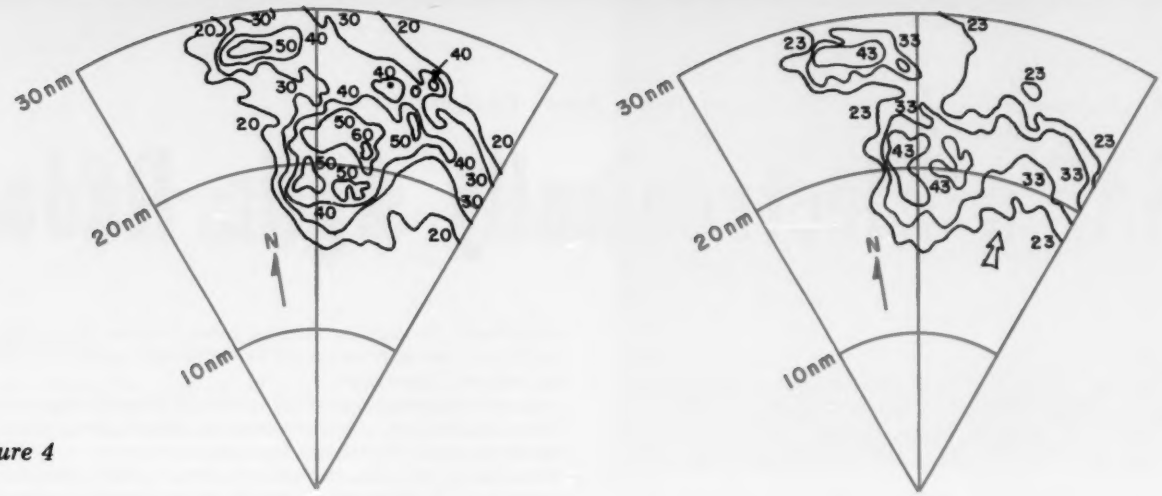

Figure 4

Radar observations of a Colorado hailstorm at 10 cm (left) and 3 cm (right). Effects of 3-cm attenuation include reduced magnitude of maximum reflectivity and distortion of shape of storm echo. See text for further discussion. (This data provided by Dr. Arthur Jameson of the Illinois State Water Survey.)

precipitation area. The crew evidently attempted to reach that edge in the shortest possible distance.

The crew's interpretation of the radar display evidently combined with their recollection of the weather encountered on their flight from Atlanta to Huntsville about two hours earlier to reinforce their belief that the storm near Rome was not excessively severe. Their only maneuver in approaching the storm was their deviation to the right of their original projected ground track to penetrate the storm at what must have appeared to be its narrowest point.

The effect of rain on radar performance is well documented in the scientific and engineering literature. Airborne weather radar users' manuals make specific reference to this phenomenon but do not discuss practical implications. A few attempts have been made to translate the signal propagation effects into practical terms by comparing reflectivity displays of 3-cm radars with those of "non-attenuating" 10-cm radars. Studies of this type were done by Merritt (1967) using the Bendix RDR-1E and the NWS WSR-57 and by Wilk, et al., (1969) using the Collins WP-101 and WP-103, Bendix AMR-150A, WSR-57, and ARSR-1D. Merritt examined theoretically and experimentally the relative performance of 3-cm and 10-cm radars in detecting thunderstorms of moderate intensity and size (reflectivity less than about 45 dBZ and horizontal dimension less than 8 nm). Wilk, et al., extended the comparison to a greater range of radar wavelengths. The radar data presented by these authors illustrate a variety of effects due to attenuation, beamwidth differences, antenna tilt, and partial beam filling by storms at long range. These studies were concerned primarily with detection of storms and secondarily with accuracy of quantitative reflectivity measurement. In the cases examined, attenuation was found not to be a major factor.

Examination of another set of radar data provides a useful comparison with the case analyzed above. The reflectivity displays shown in Figure 4 are based on data obtained from the dual-wavelength meteorological research radar operated by the University of Chicago and the Illinois State Water Survey. Maximum reflectivity observed at 10 cm was comparable to that in the Rome, GA, thunderstorm of 4 April 1977. The 3-cm display shows a maximum reflectivity about 15 dB less than that observed at 10 cm and a region of greatly attenuated reflectivity behind the high-reflectivity area. One might contemplate penetrating this storm in the area indicated by the arrow, expecting on the basis of the 3-cm reflectivity to encounter only moderate rain. The area of intense rain and possible hail (reflectivity greater than 50 dBZ) along this course is concealed due to the attenuation. Both of these examples also illustrate the distortion of echo shapes by attenuation, which is particularly important in analog displays, which provide little or no quantitative information on reflectivity or reflectivity gradients.

Whenever the actual reflectivity is greater than about 45 dBZ (rainfall rate in excess of one inch per hour), significant attenuation (greater than one decibel per nautical mile one way) can be expected, leading to major distortions of the reflectivity pattern observed with a 3-cm radar. The identification of regions of such high

(Continued on page 31)

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USAF's Electronically Agile Radar

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International Defense Review
Geneva, Switzerland

The Electronically Agile Radar, or EAR, an advanced development program sponsored by the Air Force Avionics Laboratory (AFSC), is the radar system designed exclusively for the strategic bombing mission of the 1980s and beyond. Developed by the Westinghouse Electric Corp Defense and Electronic Systems Center at Baltimore, MD, it can provide the B-52 with an affordable and effective weapon delivery and low-level penetration capability. The EAR has been designed to fit into the B-52G and H models, and in its nonredundant form, into penetration bombers such as the FB-111.

The EAR system will provide all weather operation, simultaneous presentation of multiple modes, and can be installed in any existing strategic bomber. Its principal performance features include low, medium, and high-resolution radar mapping; precise navigation capabilities; automatic terrain following using a pre-scanned, stored ground profile; and terrain avoidance for ease of manual aircraft operation in a low-level environment.

Westinghouse is under contract to build two complete EAR systems. One complete system was shipped to Boeing's Wichita plant for integration testing, and installation in a B-52G, which commenced 1 August 1978. The flight test phase began in October 1978. The second EAR unit is now undergoing mode system testing and system integration on a specially-constructed tower at Westinghouse's Baltimore facility. Testing of both systems is proceeding satisfactorily.

System Details

The EAR is a coherent multi-mode radar using state-of-the-art technology centered on its phased array antenna. It is the first airborne radar designed for production to use a two-dimensional phased array antenna. The antenna can electronically change radar beam shapes and beam positions in both azimuth and elevation virtually instantaneously. This capability allows the system to perform its numerous radar functions on a time-shared basis so that the multiple modes appear as simultaneous presentations to crew members.

The electronic beam shifting is carried out using 1,818 separate radiating elements. There is no mechanical antenna movement. The elements form a large-diameter phased array antenna which replaces the multiple smaller antennas used with existing radars. Each of the 1,818 array elements contains a phase shifter, its control electronics, and its radiating unit. The two EAR antenna systems built by Westinghouse each contain slightly differing elements — one system uses Raytheon-supplied phase shifters while the other uses Microwave Applications Group (MAG) phase shifters. The two antennas were constructed to evaluate the performance of each type of shifter, and extensive tests have now demonstrated that the antennas and both types of phase shifters have successfully met all system specifications.

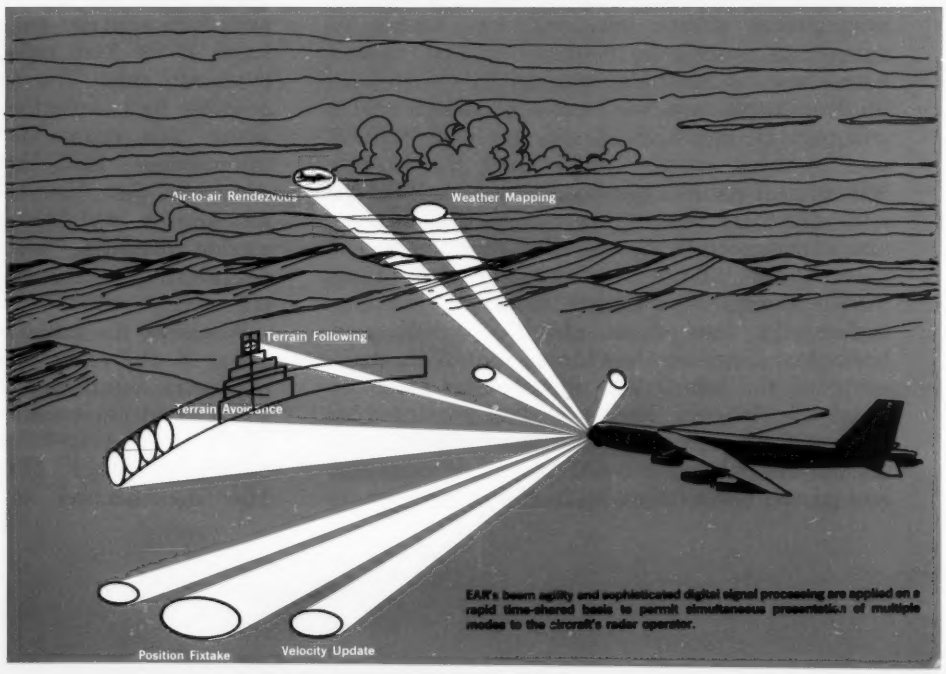
The radar includes all forward-looking functions necessary to penetrate dense enemy defenses at low altitudes, increased power and resolution for more effective stand-off weapon delivery, and advanced ECCM and nuclear hardened characteristics for improved survivability. The EAR is the first radar to be designed with radiation hardening to withstand nuclear electromagnetic pulse (EMP) exposure.

The system transmitter chain is completely redundant. If the transmitter unit fails, the standby unit is automatically substituted. Final power amplification is provided by a wideband travelling wave tube (TWT) driven by a solid-state intermediate power amplifier. Fault isolation in the transmitter chain is brought down to a removable component.

The radar signal processor provides the real-time high-speed digital computation needed to extract data in each radar mode. Programmable signal processing modules enable virtually the total signal processing power to be used in each mode. This eliminates the need for separate special-purpose circuits for each radar mode. Eleven processing modules (each containing two circuit cards) are used for the digital processing of the radar signals. An additional redundant module can be switched in to assume the functions of a failed processing module.

The radar data processor controls the entire radar system, handles the radar input and output functions, and performs built-in tests and performance monitoring. The EAR data processor is a high-speed (950 K operations/sec) variant of the Westinghouse AN/AYK-15 microprogrammable computer developed for the USAF Digital Avionics Information System (DAIS) program; it makes use of semiconductor memory.

EAR's multi-mode capability


Air-to-air Rendezvous
Weather Mapping
Terrain Following
Terrain Avoidance
Position Fixtake
Velocity Update
EAR's beam agility and sophisticated digital signal processing are applied on a rapid time-shared basis to permit simultaneous presentation of multiple modes to the aircraft's radar operator.

For Strategic Bombers

Multi-mode Capability

The EAR system's beam agility and sophisticated digital signal processing are applied on a rapid time-shared basis to permit simultaneous presentation of multiple modes to the crew. These include high-resolution ground mapping, navigation update capabilities, terrain following and avoidance, and auxiliary beacon and weather modes. A designed-in growth provision for a coherent pulse Doppler air-to-air search and track mode is included.

Mapping — The mapping modes may be used to align the inertial navigator from a cold start takeoff and to locate, identify, and designate checkpoints, offset aimpoints, or targets for precise navigation update during low-level or high-altitude flight.

EAR provides three levels of map quality. The lowest resolution map (Real Beam Ground Map) is used to begin the INS alignment process. As the navigation improves, the operator switches to a Doppler-beam-sharpened medium-resolution map. Both of these modes provide wide scan maps and serve as back-up for the remainder of the mission. For virtually all navigation purposes, EAR uses a synthetic aperture high-resolution map mode, where a high quality map is provided for identifying and accurately designating checkpoints. This high-resolution map enables a wider selection of checkpoints and a high probability of recognition. All maps are frozen on the display to permit adequate time for recognition and designation by the operator in a low-altitude penetration profile.

Position and velocity update — EAR's navigation update modes perform initial alignment and correction of INS position and velocity errors in flight. In addition to precise navigation to the target, this improved update process also affords increased survivability and more effective weapon delivery. It permits low-level flying against known enemy defenses and allows the aircrew to make full use of natural terrain features to avoid aircraft detection.

The position fixtaking mode ensures proper aircraft position by measuring the error in the predicted range, Doppler, azimuth, and elevation angles relative to a known checkpoint. If no errors are present, the checkpoint can be mapped exactly under the range Doppler cursors and exactly in the monopulse nulls. The measured displacement of the checkpoint from the predicted location is then used to update the navigation system.

The velocity update mode is continuously in operation and fully automatic. It measures the error in predicted Doppler for given line of sight directions. Its high accuracy results from two features: the data from multiple range-Doppler cells is averaged within each measurement; and an azimuth-elevation monopulse null intersection is used to define the measurement line of sight. This Doppler monopulse measurement is insensitive to terrain height variations.

Automatic terrain following — This mode permits safe ground-hugging flight regardless of geographic, weather, or jamming conditions. A principal feature of this capability is automatic aircraft flight over a pre-stored terrain profile. Thus, from long-range the radar scans and stores terrain information over discrete intervals. The aircraft is then commanded to fly over the stored profile. With this stored data, the bomber is able to continue accurate low-level flight for a significant distance, even if the radar is being jammed, or if radar silence is desired.

High power, gain, and sensitivity—plus advanced, automatic gain control and wide dynamic range—allow simultaneous measurement of very weak returns from snow-covered terrain and very strong returns. Frequency diversity techniques are used to enable accurate measurement of terrain high points and other obstacles (e.g. towers, etc.). They also allow automatic classification of signals as **terrain, rain, tower,** or **jamming.**

Safe terrain following in heavy rain is possible by using X-band circular polarization for rain cancellation, processing rejection of rain-dominated returns and high-resolution techniques. For operation in ECM conditions, the system uses of wide bandwidth, high resolution, low side-lobes, jammer detection, plus processing and gating techniques.

Terrain avoidance — This mode provides information to the pilot on terrain height over a wide azimuth scan angle. This allows safe, manual maneuvers outside the planned flight path. There are two types of terrain avoidance displays: the three transverse profiles simulate what the crew might see through the windscreen in the form of three ridges, dimmed by haze; the two-contour plan-PPI gives a plan of terrain heights to either side of the aircraft's anticipated path. Tower positions are flagged on the PPI; similarly, jammer positions are flagged on the transverse profiles.

Weather and beacon modes — The weather detection mode is a non-coherent pulse mode used to alert the crew to heavy rain or snow storm cells. The beacon mode is used for navigating, position fixtaking, and for locating and rendezvous with refueling tankers. Operation is compatible with interrogating, detecting, locating, and displaying beacons used on B-52s, KC-135s, FB-111s, etc. Variable delay compensation is used so that true beacon range is displayed.

Equipment Redundancy Maintenance

From the outset, emphasis has been on developing a system providing high performance without high cost. Both new and highly refined existing technology have been applied. In addition, selected use of hardware redundancy insures the high probability of success required for the penetrating mission. With minimal impact on size, weight, and power requirements, the redundancy-structured EAR achieves a 500% increase in mission *MTBF with only a 20% increase in hardware requirements and acquisition cost. For a 15 hr mission, EAR provides an equivalent MTBF of 620 hr, a 98% probability of mission success.

Structured redundancy within the radar eliminates complete duplication, which is costly but currently required with existing terrain following radars. Since much of the EAR hardware is used in more than one radar mode, redundancy for terrain following also adds redundancy to the other EAR modes. In addition to redundancies already mentioned in the transmitter and processor, a spare receiver channel is provided as a back-up should one of the two in-line receiver channels fail. EAR sub-systems which are not redundant have a "fail soft" capability. For example, a number of radiating elements in the antenna can fail and not degrade performance below acceptable limits.

The cost of maintenance for EAR has been projected to be less than one-third the existing maintenance costs for radars in strategic bombers. For this, a two-level maintenance concept is being proposed instead of the conventional three-level system of existing avionics. This approach reduces the manpower required for support, the cost of spares stocking, and the amount of test equipment required. EAR has been designed so as to eliminate the need for complex flight-line test equipment, as well as the need for intermediate level maintenance.

EAR design incorporates the capability to automatically detect faults through built-in test (BIT) functions, as well as isolate these through fault isolation tests (FIT) to a low-level assembly called a line-replaceable module (LRM). This BIT/FIT capability was achieved through miniaturization techniques that allow the packaging of a entire functional entity (such as a receiver, or analog/digital converter) into a small module. This capability is further enhanced through expanded use of digital technology to improving testing routines and allowing time-sharing of onboard computers for both radar and test functions. The LRM is a smaller assembly than the standard line-replaceable unit.

* *MEAN TIME BETWEEN FAILURE*

F-4G advanced wild weasel

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In 1978, TAC received the first of a new generation of Wild Weasel aircraft. The 39th Tactical Fighter Training Squadron, George AFB, California, marked the beginning of a new era in enemy defense suppression by accepting the first F-4G.

With the latest electronic hardware to detect, locate, and identify, the F-4G can home in on radio frequency emitters with a much higher degree of accuracy than previously obtainable. In addition, it has a larger payload capacity than previous Weasel aircraft and can carry a greater variety of weapons. The aircraft also retains the ability to carry bombs and precision guided bomb units for air-to-ground missions.

To accomplish this role, the airplane has taken on a new look, both externally and internally. To the Phantom buff, the external change is obvious, from the pronounced chin pod and torpedo-shaped vertical fin pod to the large number (56) of added antennas. The internal changes consist of a number of added and revised systems, the heart of which is the AN/APR-38 Radar Homing and Warning System.

The Wild Weasel mission is not completely new to the Phantom in that some time ago a small number of F-4Cs were converted to that configuration. Now, selected F-4Es are being converted to F-4G Advanced Wild Weasels. A number of factors influenced the selection of the F-4E for this conversion—it is more maneuverable; it has survivability improvements installed; and it is a much newer aircraft. The aircraft are being converted at Ogden Air Logistics Center and are picked by fatigue index. In all, 116 aircraft will be converted, with 96 going to combat units and the remainder being devoted to training and continued testing.

The modification program involves the incorporation of over 100 separate TCTOs to bring the aircraft into the base line F-4G configuration. The basic Wild Weasel conversion involves structural, hydraulic, pneumatic, electrical and equipment changes to accept the AN/APR-38 system. To augment armament capabilities, new weapons launchers are installed. For structural fatigue improvement and enhancement of several systems, a number of TCTOs beyond the base line configuration were also incorporated in the overall program.

Though the internal gun has been removed, the F-4G can carry a variety of munitions and antiradiation missiles. The AIM-7F and AIM-9 air-to-air missiles still can be carried for self-protection against enemy fighters. The aircraft has been cleared to carry the AGM-45 Shrike, AGM-78 Standard Arm, and AGM-65 Maverick series including the imaging infrared (IR) version. Use of IR Maverick will greatly enhance the night/bad weather capability of the F-4G. Testing of the AGM-88 HARM/F-4G interface is scheduled to start in the near future. Existing aircraft wiring for this interface is adequate and programming the computer for compatibility will be the only requirement.

While significant instrumentation changes have been made in the front cockpit, it is the aft cockpit—home of the Electronic Warfare Officer (or "Bear" as he is known in the Weasel community)—in which changes are especially pronounced. Figure 1 shows the EWO's main instrument panel and left and right consoles; Figure 2 shows the new configuration of the

pilot's main instrument panel and left console. (Both figures depict only items peculiar to the Wild Weasel configuration; however, for overall mission capability many new components have been added and others relocated.)

A digital computer receives, processes, and displays emitter information to the crew in the form of CRT presentations, digital readouts, advisory/warning lights, and aural tones. Computerized information is also provided to the weapon system for use in munitions delivery, and to various instruments used by the crew to perform delivery maneuvers. This frees both the pilot and the EWO of many analytical and manual duties once required, presents them with an accurate view of the enemy's defense environment, and allows them a flexibility never before possible in seeking out and destroying those defenses.

The AN/APR-38 beam receivers (9 inch arrays), for obtaining range and azimuth information, are located on the chin pod nose, left and right sides of the chin pod, and on the vertical fin looking aft. The range and azimuth information for all ground threats received is displayed on the plan position indicator (PPI), one of three scopes in the aft cockpit. (There is a repeater PPI in the forward cockpit.)

Priorities are assigned to the top 15 targets by the computer. Threats are indicated by letter and number symbols. A triangle is placed around the highest priority threat determined by the computer classification table. If desired, the EWO may override and designate a threat the Weasel will work. This threat is designated by a diamond around the symbol.

Figure 1

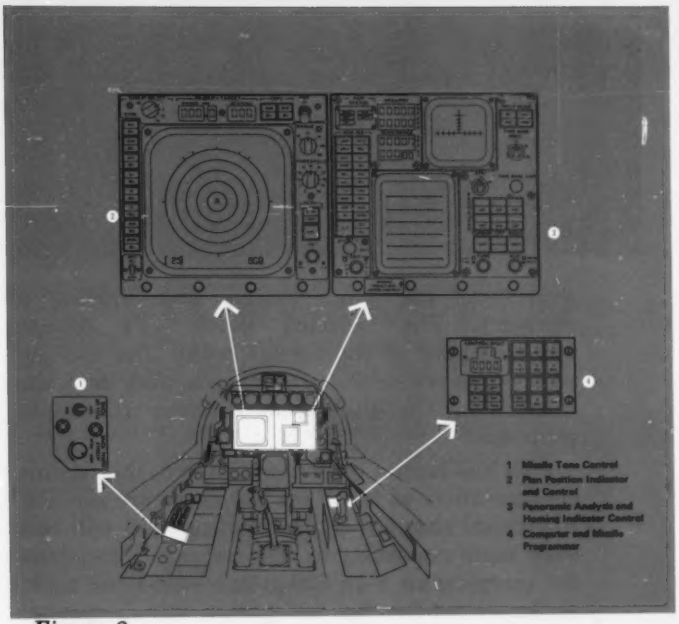
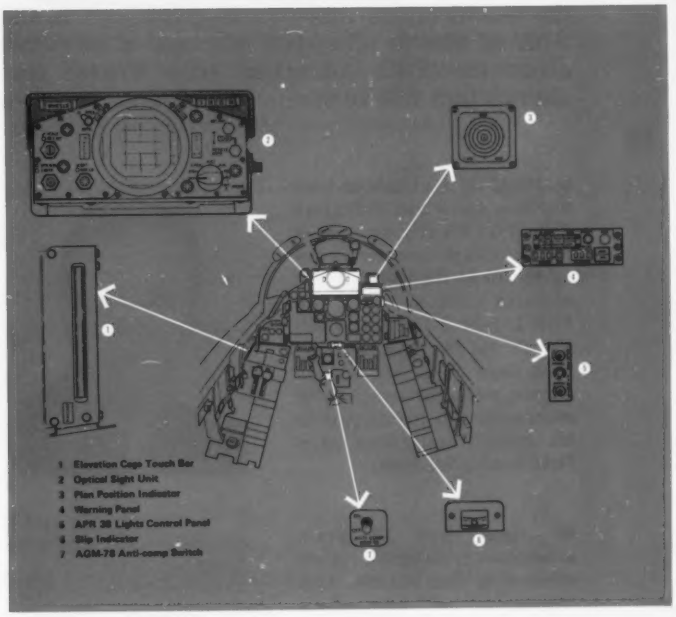

1 Missile Tone Control
2 Plan Position Indicator and Control
3 Panoramic Analysis and Homing Indicator Control
4 Computer and Missile Programmer

Figure 2

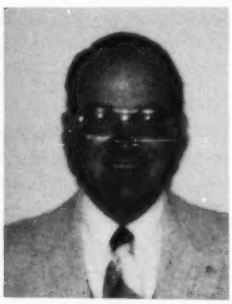

1 Elevation Cage Touch Bar
2 Optical Sight Unit
3 Plan Position Indicator
4 Warning Panel
5 APR 38 Lights Control Panel
6 Slip Indicator
7 AGM-78 Anti-comp Switch

The homing and warning computer, one of the most important parts of the system, can be reprogrammed to include new or changed threats. The modified optical sight indicates the radar emitter position with its red reticle. Ground track of the aircraft in azimuth is indicated by a green cross caged in elevation to the radar boresight of the aircraft. The Weasel pilot can bomb "blind" by positioning the green cross over the reticle,

depressing the bomb button, and starting a recovery. The selected store will release automatically at the correct point. The mission recorder provides the capability to play back the mission on the ground for training and study purposes.

This has been a brief description of the current configuration of the F-4G but there are already additional changes on the horizon that will add even more capability to this aircraft. Provisions for carrying an F-15 600-gallon centerline tank, an improved inertial navigation attack system, and an airborne video tape recorder are a few of the modifications that can be considered near. With all this to offer, you will hear a lot more about the F-4G Advanced Wild Weasel, an aircraft that will be around a long time.

In 1974, Mr Hart retired from the Navy and joined McDonnell Aircraft Co. His 18 years with the F-4 includes aircrew experience as an RIO on the F-4A-B-J, and avionics maintenance on F-4H-1, F-4A-B-J-G, and RF-4E aircraft. He has been with the F-4G since 1976, and was an aircrew instructor and APR-38 maintenance instructor prior to his present assignment as a Field Service Engineer.



Mr Harty has 22 years experience in preparing retrofit documents. This includes work on the F2H Banshee, F-3H Demon, F-101 Voodoo and the F-4 Phantom II. He has also served as a special retrofit program consultant to the Imperial Iranian Air Force and to MBB of Germany. A section Manager for McDonnell Aircraft Co., he is also a major in the Air National Guard.

Proportion

Captain James C. SIPPEL
451 FTS/DO
Mather AFB, CA

This method of time control provides corrections to groundspeed that are proportional to the amount of time available to hold the correction. It can also solve for the time to hold any specified correction. The key to this method is the following formula:

$$\frac{\text{TIME OFF}}{\text{TIME TO HOLD}} = \frac{\text{DEVIATION}}{\text{FLT PLN GS}}$$

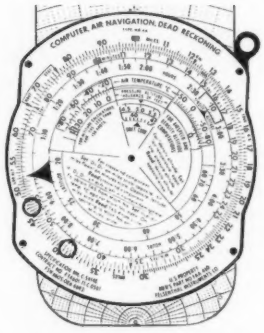
DEVIATION means the difference between actual and flight planned groundspeed (FLT PLN GS). TIME TO HOLD means how long the DEVIATION must be held to correct for the amount of TIME OFF.

You can choose when you want to be back on time and then spin out the necessary groundspeed or if you already have a correction in, you can spin out the time required for your present groundspeed to get you back on time.

WHAT SPEED CORRECTION?

Let's say you compare the actual arrival time at a checkpoint to the flight planned time and find that you are 47 seconds late. The time to the next checkpoint is 9 minutes. The flight planned groundspeed is 450 knots and you want to be on time again by the next checkpoint. To find the needed groundspeed, set the TIME OFF (47 seconds) over the TIME TO HOLD (9 minutes or 540 seconds) and read the DEVIATION above the FLT PLN GS (450 knots).

$$\frac{47}{540} = \frac{39}{450}$$



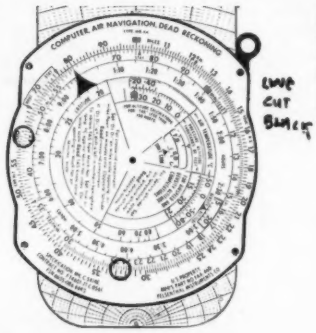
The DEVIATION is 39 knots. Since you're late, the groundspeed needed is 39 + 450 = 489 knots. This will regain 47 seconds if held for 9 minutes.

al Time Control

Notice that TIME OFF and TIME TO HOLD both must be in the same unit, either seconds or minutes. The hours scale printed inside the minutes scale on the MB-4 computer makes it easy to convert from minutes to seconds and vice versa on the TIME TO HOLD.

HOW LONG TO HOLD A CORRECTION?

Say the TIME OFF is 3 minutes 15 seconds and you want to get back on time as soon as possible. Get the maximum indicated air speed allowed for the mission and use the resultant groundspeed to figure the DEVIATION. Let's say you get 510 knots and the FLT PLN GS is 450 knots. The DEVIATION is 60 knots. To find the TIME TO HOLD set 60 over 450 and read under 3.25 minutes.



$$\frac{3.25}{24.4} = \frac{60}{450}$$

The TIME TO HOLD is 24.4 minutes.

LOW LEVEL

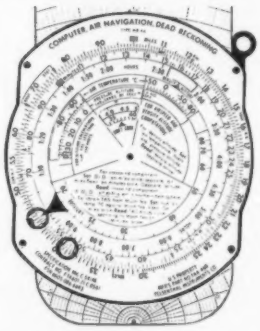
To simplify using this method at low level, notice that if both numbers on top are equal (TIME OFF and DEVIATION) then both numbers on the bottom must be equal (TIME TO HOLD and FLT PLAN GS).

At each low level checkpoint, compare the actual time of arrival to the flight planned time and determine the TIME OFF. For this example, the TIME OFF is 15 seconds early. FLT PLAN GS is 300 knots. The trick is to make the two top numbers (TIME OFF and DEVIATION) equal in the formula. The reason for this lies in the mathematics of the equation: with the top two numbers equal, the bottom two are also equal. This means that the TIME TO HOLD will be numerically equal to the flight planned groundspeed. In this example, to make the top two numbers equal you must have a DEVIATION of 15 knots and it must be lower than flight planned groundspeed. Use an indicated air speed that will produce a groundspeed of 285 knots and the TIME TO HOLD will be numerically equal to the FLT PLN GS. Since FLT PLN GS is 300 knots, hold the correction for 300 seconds and then return to flight planned groundspeed. All the corrections made on one mission are held for the same length of time.

$$\frac{15}{300} = \frac{15}{300}$$

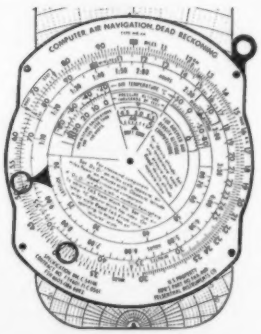
WHY IT WORKS

The proportion used in this time control method is derived from the proportion used to spin time, distance, and speed problems. To determine how long it would take to fly 39 nm at a groundspeed of 450 knots, put the groundspeed over 60 minutes and read the time under the distance.



$$\frac{450}{60} = \frac{39}{\text{TIME}}$$

This allows you to find the time required to fly any distance at 450 knots without adjusting the computer. The principles of algebra allow the equation to be written another way without destroying the equality.



$$\frac{\text{TIME}}{60} = \frac{39}{450}$$

You could set the groundspeed under the distance and read the time required over the speed index. This is the proportion used for the time control method.

If an aircraft flies 39 knots above flight planned groundspeed for one hour it will be 39 nm farther down course than if it had flown at FLT PLN GS. To find the time gained in that hour, compute how much longer it would take to fly that additional 39 nm at FLT PLN GS. Both of the above equations will solve that problem but the second equation sets up the hourly rate of time gain so that you can also check the time gained for any part of an hour without adjusting the computer.

Capt Sippel has a degree in Physics from Iowa State University. He completed UNT in 1974, and subsequently was assigned to Korat AB, Thailand, as an AC-130H low light level TV operator. Assigned to Mather AFB, Capt Sippel presently is an instructor in advanced navigation.

NAVIGRAMS

CAPTAIN DAVID R. CHESSER has been selected as the Outstanding UNT Graduate of 1978 and the recipient of the Daughters of the American Colonists Award. This annual award consists of an engraved silver tray and a megaquartz watch. Captain Chesser, now an FB-111 navigator at Plattsburgh AFB, compiled an impressive record in competition with 571 other graduates. Congratulations from THE NAVIGATOR!

THE ATC COMMANDER'S TROPHY is presented to graduates of UNT for outstanding academic achievement. Our congratulations to these recent winners:

	Class	Hometown	Acft	Squadron/Base
2d Lt Thomas H. Thacker	79-08	Dayton, OH	F-111	20 TFW/Upper Heyford, England
2d Lt Drew R. Fisher	79-09	Centerville, OH	C-130	21 TAS/Clark AFB, Philippines
2d Lt Edward M. Poling	79-10	Newark, DE	C-5	325 MAS/AFRES/Dover AFB DE
2d Lt Brian J. Dillon	79-11	Albany, NY	RF-4	26 TRW/Zweibrucken AB, Germany
2d Lt John D. Manzi	79-12	Spring Lake, NJ	F-111	20 TFW/Upper Heyford, England
2d Lt Richard A. Devanney	79-13	Cincinnati, OH	F-4	8 TFW/Kunsan AFB, Korea
2d Lt David W. Gapp	79-01R	Tucson, AZ	RF-4	26 TRW/Zweibrucken AB, Germany
2d Lt Gregory A. Feest	79-02R	Racine, WI	F-111	20 TFW/Upper Heyford, England

A SECOND ANNUAL NAVIGATION SYMPOSIUM is planned 5-7 September 1979 at the USAF Academy. Last year's was successful in establishing navigational cross-talk among the MAJCOMS. To maximize the information flow, a summary of this year's conference will be published in THE NAVIGATOR magazine. (For information about attending, presenting papers or agenda items contact Captain Robert Sallee, USAFA, USAFA, AUTOVON 259-3790.)

STATISTICALLY 80% OF ALL LIGHTNING STRIKES happen when the aircraft are within eight degrees C of the freezing level, in the clouds, in precipitation, and experiencing turbulence. (THE MAC FLYER, April 1979)

SEVERAL MUSEUMS are interested in your contributions of equipment, documents or ideas concerning aerial navigation. For information contact Captain K. N. Giffard, the Silver Wings Museum, 323 FTW/DOTN, Mather AFB, CA 95655; or Mr James R. Luntzel, Jr., San Diego Aero-Space Museum, Casa Del Prado, Balboa Park, San Diego, CA 92101. For inputs to MAC's planned airlift museum contact HQ MAC/HO, Scott AFB, IL 62225.

ALCM FLIGHT TESTS at Edwards AFB are being supported by F-4E and EC-135N Advanced Range Instrumentation Aircraft (ARIA) modified by technicians and engineers of the 4950th Test Wing at Wright-Patterson AFB. The primary role of the F-4 chase aircraft is remote command and control of the missile. The EC-135N ARIA, flying 10 to 30 miles behind the missile, will be the primary relay center for ALCM telemetry data. The information is received, recorded, and then relayed from ARIA to five ground stations along the ALCM flight path and sent to Edwards AFB for real-time processing.

LOST and FOUND

Found

Once again, many of you correctly identified the ditching and recovery sites for our haplessly misnavigated and lost crew from the Spring, 1979 issue. (Fortunately, the principle of the aisle average applies to such cases.) By random drawing from the correct entries, the following three were selected as winners of the naugahyde DR kit holders:

Captain Rob G. Williams
34 TATG/TTDA
Little Rock AFB, AR 72076

Capt Michael B. Manning
ASD/ENECC
Wright-Patterson AFB, OH 45433

Second Lieutenant Fred W. Niblock
407 AREFS
Loring AFB, ME 04751

Congratulations to the winners and all the others who correctly identified:

Silhouette Island	*04.30 S*	*55.14 E*
Mahe Island	*04.34 S*	*55.27 E*

Lost

On the long way home the rescue HC-130 navigator decides to ask a professional question of our now world famous lost and found navigator. He wonders if he can save fuel by climbing from 22m to 23m even though there may be an additional headwind component at 23m. At best range cruise airspeeds and current gross weight of 140,000 lbs, the navigator asks how much additional headwind component can he stand and still save gas. Declaring, "I can navigate anything," Lost and Found borrows the navigator's TOs to work up the answer. To the nearest knot, what is your answer to this tricky question?

Mail your answer, with all your steps to reach the solution to:

Editor, THE NAVIGATOR Magazine
323 FTW/DOTN
Mather AFB, CA 95655

On 15 Sep 1979, three names will be drawn from the lot of correct answers. The three winners will recieve a free year's subscription to THE NAVIGATOR.

coordinating with NORAD for ECM clearances

Captain John B. LINNSTAEDT
4017 CCTS
Castle AFB, CA

Excluding Alaska, the North American continent is divided into seven NORAD regions numbered 20 through 26 (see the attached map). Each of these regions has a controller, called a Radar Inputs and Countermeasures Officer (RICMO), who directs and coordinates counter-countermeasures activities within his region. He is assisted by a Radar Inputs and Countermeasures Technician (RICMT) and together they interpret information provided by long-range radar sites within the region. Aircraft detection from these radars is forwarded to the semi-automatic ground environment (SAGE) computer facilities which are at NORAD region headquarters. Computer displays provide RICMO and region weapons controllers with information on location, altitude, heading, speed, and numbers of aircraft within a given region.

Instead of the overlapping interior and exterior radar coverage of the 1950s, the command now has a perimeter system of aircraft detection radar sites along US and Canadian borders. If a hostile aircraft were detected, the region battle staff would assemble and information would be forwarded to NORAD headquarters. Directions for meeting an air attack come from the NORAD Commander-in-Chief who monitors the situation from his headquarters deep in Cheyenne Mountain near Colorado Springs, Colorado. Here, computer displays can build a picture of North America that will show tracks of suspected or known enemy air activity. To counter manned bombers, ADCOM has six Air Force squadrons of F-106 Delta Darts, which are complemented by five F-106, three F-101 Voodoo and two F-4 Phantom squadrons flown by the Air National Guard and three Canadian CF-101 squadrons, in addition to TAC augmentation forces. These interceptors can be flown semiautomatically, by the SAGE computer data link, to within range of the intercept target, freeing the pilot for target acquisition. Voice control procedures are used when data link is not available.

The region weapons controllers/radar inputs and countermeasures personnel maintain liaison with air traffic control agencies, air defense artillery and surface/naval fire units to insure safe passage of friendly air traffic and to relay threat warning and ECM data to appropriate agencies. The radar inputs and countermeasures

Editor's Note: This article explains why it is sometimes difficult to obtain ECM clearances. The author uses the B-52, as an example, but we hope all aircrew members will find it interesting and useful.

personnel also direct the operation of radar site ECCM equipment to negate the effectiveness of enemy ECM. During air defense exercises, a force of electronically equipped aircraft exercises the defense environment and simulates very closely the expected tactics of an attacking force.

This brief look at the work of NORAD weapons controllers/radar inputs and countermeasures personnel will help to introduce reasons you may have trouble getting ECM clearances. The first reason is due to radio coverage in the CONUS. (I have tried to illustrate this problem on the NORAD radar and radio sites map.) According to the B-52 flight manual, the range of the UHF radio is projected at approximately 210 nm for a B-52 flying at 30,000 feet. Obviously this does not account for mountains or other obstructions to line-of-sight transmissions. Thirty thousand feet was chosen as a normal training mission altitude at which clearance would be obtained, but again the radio range would be reduced at lower altitudes. Regardless, I have used the full 210 nm projected range from the radio sites to determine the expected radio coverage within the continental US. Looking at the map you can see that because of NORAD's shift to a perimeter defense concept, coverage is limited to the perimeter of the US.

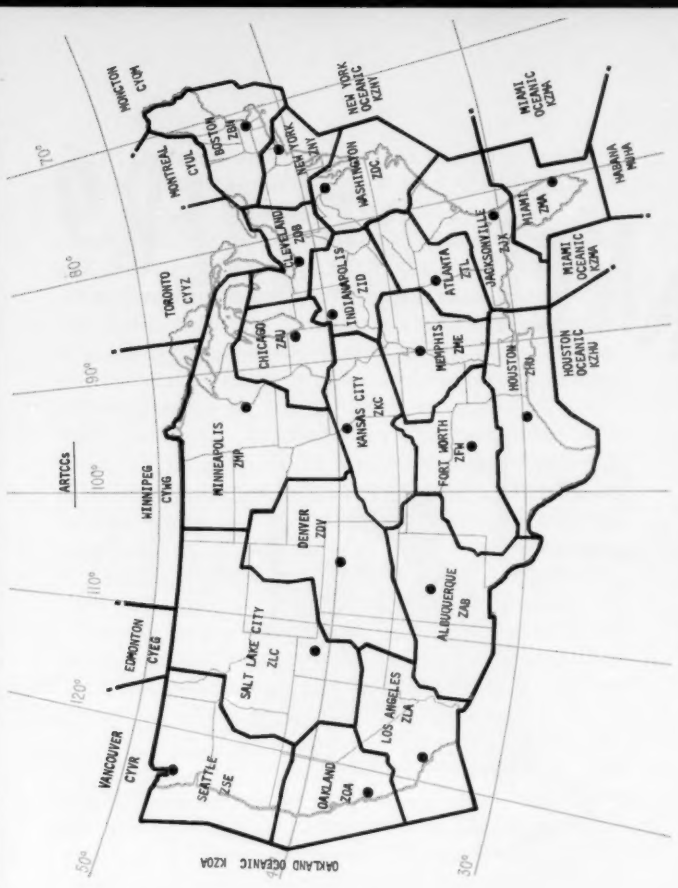
However, in accordance with AFR 55-44 and FAA procedures, aircraft may obtain clearances from air traffic control centers within the CONUS open area (FAA Handbook 7610.4D, Part 6, Chapter 16, Section 3). I have drawn the boundaries where this is permitted on the same map. At least two areas, one just west of Lake Michigan and another small area in Utah, are not covered by either ARTCC or NORAD! (I have illustrated the January 1978 FAA Handbook change, and comparing the July 1975 SAC Supplement with AFR 55-44 shows that this problem recently has been significantly reduced.) But there is more than meets the eye. Not all NORAD radio sites in the southern air defense area operate on Air Intercept Control Common (AICC) 364.2, the normal coordination frequency, and this may result in additional radio coordination problems for SAC aircraft operating in this area. This was a particular problem in the southeast portion of the 26 NR where all four radio sites use frequencies other than AICC.

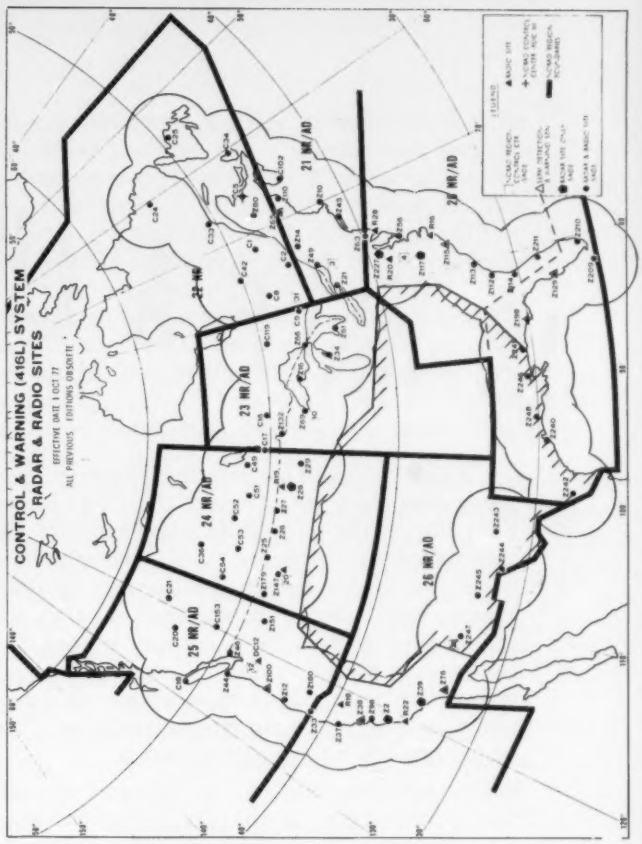
A unique situation also exists in the 20 NR. The East Coast uses the call sign "Fertile" and is headquartered at Fort Lee, VA. However, from the center of Florida west the region is controlled by a subdivision of the 20 NR, Tyndall NORAD Control Center, that uses the call sign, "Dunmore." (I have indicated this division by a dashed line through the center of Florida on the map.) Therefore, a SAC aircraft using call signs listed in SACR 100-24, Vol V, would be using the wrong ones in the southern US.

Another problem occurs in obtaining NORAD ECM clearances during the Performance Analysis by Continuous Evaluation (PACE) program for exercise of the defense environment. This penetration exercise by designated aircraft occurs about every other day, and during this period, RICMOs will be unable to grant ECM clearances for about two hours. In this connection, one must also remember that NORAD is most concerned about objects penetrating the US from outside the boundaries, so in cases of conflict between granting ECM clearances and defending our borders, the latter rightfully receives the greater attention. Of course there may be other factors, but these are the main reasons I have found for being unable to obtain clearances.

Now let's look at ways to work around these problems. As a new EWO I often had trouble contacting NORAD when outside the ARTCC clearance region. After several tries on 364.2 MHz I would ask the ARTCC to contact NORAD. This worked only infrequently and, by then, we were usually out of the region and required to do something else. Finally, one day our Wing EWO got some HF frequencies from Fertile Control which I figured would be a sure way to get clearance. Unfortunately, after a few flights I was discouraged again because there was no answer. Next came a telephone number for Fertile Control which led to several discoveries. I learned more during my PCS move to Castle AFB by stopping at NORAD Headquarters in the Childlaw Building, Colorado Springs. The following should help your coordination too. First realize that UHF radio clearance is accomplished with the weapons controller in the NORAD Region Control Center (RCC) who then coordinates with RICMO/RICMT, the ARTCC, the NORAD Combat Operations Center and any applicable restricted geographical areas listed in AFR 55-44. Some NORAD regions covering coastal areas also have HF radio capability used for E3A AWACS flights. However, HF use should be precoordinated since it is not continuously monitored. Contact also can be made on a discrete UHF frequency (or HF) while airborne by asking ARTCC to obtain the frequency from the appropriate NORAD RCC. The ARTCC and RCC have direct lines to each other.

If mission planning reveals that ECM clearance will be needed in an area outside NORAD coverage and ARTCC jurisdiction, then





precoordination probably will be the best option. This is authorized by AFR 55-44, "...ECM clearances should be requested as early as practicable prior to proposed initiation of ECM activity. In-flight clearances will not be required if prior coordination and agreement have been established with the proper NORAD agency. Clearance requests will include:

(1) Aircraft call sign and altitude.

(2) Type of ECM, i.e., buzzer, stream, and/or burst.

(3) Frequency bands and channels affected.

(4) Area and duration of ECM activity."

A telephone call will solve most problems during normal training missions, but remember that for joint training missions NORAD/SACR 51-25 states "...Except for SNOWTIME missions, specific clearance will be obtained for use of chaff when in-flight ECM clearance is requested and will be confirmed in flight when the use of chaff has been precoordinated..."

Message coordination normally would be accomplished with the NORAD Region staff agency but telephone coordination can be accomplished with each NORAD Region Operations Section on a 24-hour basis. I have included a list of AUTOVON telephone numbers for the NORAD Region RICMOs.

NORAD REGION	CALL SIGN	AUTOVON TELEPHONE
20th, Fort Lee AFS, VA	Fertile	687-4008, Ext 228/229/746
Tyndall Control Center, Tyndall AFB, FL (Subdivision of 20th)	Dunmore	970-2426
21st, Hancock Field, Syracuse, NY	Incognito	587-9110, Ext 5710/5228/5229
22d, North Bay, Ontario, Canada	Irradiate	625-4228/4249
23d, Duluth IAP, MN	Goliath	825-8731
24th, Malmstrom AFB, MT	Huntress	632-6785/6228
25th, McChord AFB, WA	Top Soil	976-6728
26th, Luke AFB, AZ	Arizona Pete	853-6611, Ext 720/228

To conclude I have included a checklist-size map of air traffic control (ATC) facilities. You should find this useful since many clearances come from these facilities. Depicted are the ATC boundaries and call signs along with their ICAO identifiers.

Capt Linnstaedt graduated from the University of Houston with a degree in Chemical Engineering. After two overseas assignments as a munitions maintenance officer, he entered navigator and EWO training. During his first rated assignment at Blytheville AFB, he served on Stan/Eval. Capt Linnstaedt presently is an instructor with the 4017 CCTS, Castle AFB.

IS HALF A CHANCE BETTER?

Editor's Note: This article is extracted from a paper describing the effects of the 1974 change in Title 10 of the US Code allowing Air Force navigators the opportunity to command flying units. The author reasons that unless navigators attain supervisory experience at the lower operational levels, they cannot expect to be competitive for selection to flying command. In the portion that follows he recommends a course of action to improve our effectiveness as officers, as navigators, and as commanders.

Major Roger M. MILLER
EW Div — OJCS/J-3
The Pentagon
Washington, DC

There are some affirmative actions that can be taken to eliminate the obstacles facing the navigator in his quest to qualify for a flying command. First and foremost, positive action must be taken to eliminate discriminatory practices based on invalid tradition. This is a major undertaking. Although the ultimate responsibility for change lies with commanders, initiation of the action belongs to navigators. For instance, if navigators had not worked for a change in Title 10, we would not have the chance today to compete for command of a flying unit. The secret to success, in my opinion, is to be consistent, not impatient. Therefore, navigators must continue to seek the previously forbidden positions, question poor practices and press for change. Admittedly such actions will not be embraced by the timid, but for those who truly seek the challenge of a flying command, there is no other alternative. However, before charging off to right the wrongs, some prerequisites must be met. It would be foolish to seek change if one is not ready and fully prepared to meet the responsibilities resulting from the change.

Individual preparation to assume operational command/supervisory positions is the key factor that will support change. Such preparation involves three independent yet inseparable actions. The first is to build a strong foundation of operational knowledge. The navigator must be an expert not only in assigned duties and rated specialities, but also in the larger spectrum of flight operations and management. This requires detailed study of the many regulations, manuals, technical orders, policies, and procedures that govern the various levels of flight operations. The importance of this knowledge cannot be overstressed. A navigator should ask himself, "If I were assigned as a SOF and/or Mission Commander today, do I have the knowledge necessary to successfully carry out the assigned responsibilities?" If the answer is no, then additional work is required. Digging out all the pertinent source documents for study is not an easy task. Ask for help. Squadron commanders, operations officers, and flight commanders can assist in identifying the right materials to study.

In conjunction with expanding knowledge, a second action can be taken — broadening operational experience. For the navigator this is a tough problem. Experience in operations and

flight management reinforces decision-making ability and judgment. These two abilities are of the utmost importance for supervisory and command positions. Analyze present duties to determine the operational management experience to be gained. For instance, navigators can gain valuable decision-making experience in the air by aggressively performing navigational duties and by keeping constantly aware of critical developments in the mission. In addition, some jobs presently available to the navigator will broaden experience in operations management. Positions such as flight scheduling and training are excellent jobs to expand experience for future application.

Finally, operational/supervisory experience can be gained, to some extent, vicariously. Observe flying supervisors as they conduct their tasks, paying particular attention to decisions and the logic used in making their decisions. For example, time spent with a unit operations officer or SOF can be most enlightening. Witnessing the supervisory process and talking over the significant decisions may be the next best thing to actually being assigned the position. After continued exposure, knowledge of the operational regulations and manuals previously studied will be reinforced. Admittedly, this approach does not solve the experience problem for the navigator, but it will help prepare for future eventualities. The navigator's final action to prepare for the future is to insure top performance of assigned tasks.

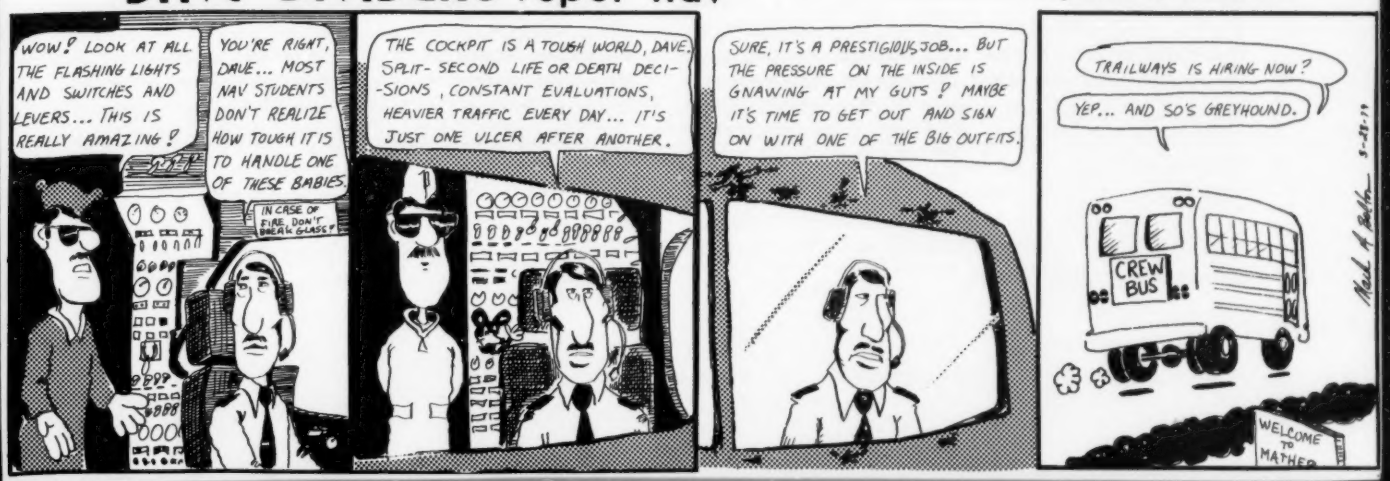
Performance, as an all encompassing measure, is the most important factor for selection to a command position. Remember, a top performer achieves excellence in all tasks, even though some assigned duties may seem menial. For example, I have known some fine young navigators who were top performers in the air, but when assigned the additional task of squadron duty officer, an administrative duty, these same men turn in a mediocre performance. They undoubtedly felt the duty officer position was a menial task and did not deserve their best effort. Whether or not the task was menial is totally irrelevant. The squadron commander and operations officer relied heavily on the duty officer to provide daily continuity. Unwillingness to render top performance in carrying out this task could not reinforce the commanders' confidence to select these navigators for jobs of greater responsibility. The point is, do all jobs well! I believe this is especially important. Navigators must build confidence and respect in their ability to get the job done right. Once commanders have that confidence, the task of changing policies, practices, and attitudes will be much easier.

To briefly conclude, although navigators have the opportunity to command flying units, they have not had an equal opportunity to be selected. This is a result of limited exposure to the lower level operational positions needed to gain the experience and background necessary to meet best qualified status. This inadequacy is now the subject of command attention, but navigators must take responsibility by preparing themselves. Those navigators with the knowledge, experience and proven performance will pave the way and achieve equal opportunity to compete for flying command.

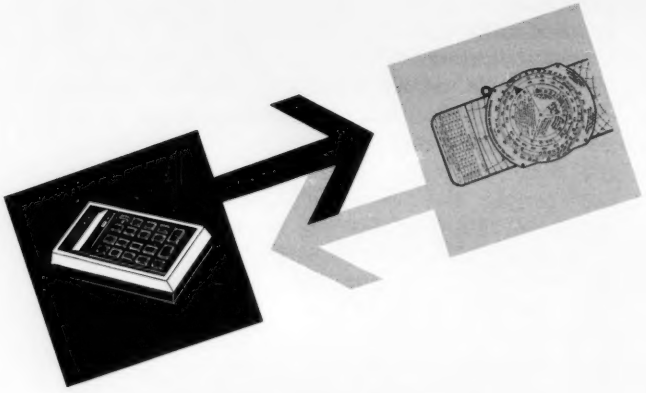
Maj Miller has a master's degree in Business Administration from Golden Gate University. His early career involved flying B-52s as an instructor EWO in both the 5th Bomb Wg and the 320th Bomb Wg. A qualified F-4E WSO, he recently completed a tour as Flight Commander in an F-105G Wild Weasel Sq. Maj Miller now serves as Air Operations Officer, Electronic Warfare Div, Office of the Joint Chiefs of Staff.

DAVE DIVIDERS 'super nav'

by 2d Lt Mark Bolton


WOW! LOOK AT ALL THE FLASHING LIGHTS AND SWITCHES AND LEVERS... THIS IS REALLY AMAZING!
YOU'RE RIGHT, DAVE... MOST NAV STUDENTS DON'T REALIZE HOW TOUGH IT IS TO HANDLE ONE OF THESE BABIES.
IN CASE OF FIRE, DON'T BREAK GLASS!
THE COCKPIT IS A TOUGH WORLD, DAVE. SPLIT-SECOND LIFE OR DEATH DECI--SIONS, CONSTANT EVALUATIONS, HEAVIER TRAFFIC EVERY DAY... IT'S JUST ONE ULCER AFTER ANOTHER.
SURE, IT'S A PRESTIGIOUS JOB... BUT THE PRESSURE ON THE INSIDE IS GNAWING AT MY GUTS! MAYBE IT'S TIME TO GET OUT AND SIGN ON WITH ONE OF THE BIG OUTFITS.
TRAILWAYS IS HIRING NOW?
YEP... AND SO'S GREYHOUND.
CREW BUS
WELCOME TO MATHER

The NAV CALCULATOR?



Captain Bruce J. SAVAGLIO
3900 CPUSS/ADOW
Offutt AFB, NE

A number of Air Force navigators have been using programmable calculators since their appearance a few years ago. Their excellent results have promoted changes in command policy towards calculator use in flight. Many commands are including procedures for calculator use in their navigation training manuals. SAC, for example, is studying various makes and models to determine which type to purchase for command-wide issue, and some local units have already started issuing calculators to flight crew members. What this means to navigators is that the flight calculator is here to stay and is going to be playing a larger role in the future of air navigation.

At present, most navigators are not using calculators and are not convinced that this device has a legitimate place in the navigator's bag of tricks. To some critics, using this miracle of microelectronics seems much more complicated than the familiar MB-4. To others, the rush to computer navigation seems filled with dangers from unseen gremlins that cause undetectable errors leading navigators into situations from which they cannot recover. And still others warn of the problem that can result from relying entirely on a mechanical device that might simply run out of power.

These criticisms are raised by people concerned about the value of a device that is going to directly affect their jobs. They are legitimate questions that deserve answering. As a navigator who has been using a hand-held computer for navigation, I will try to answer these questions and describe some of the advantages of using a calculator.

"A CALCULATOR IS MORE COMPLICATED TO USE THAN AN MB-4"

Of the several makes and models of calculators that can be used for navigation, some are flexible enough to be called computers. These can be programmed for a variety of tasks, only one of which is navigation. To someone without an interest in computers, they are formidable in appearance, and seem very difficult to operate. They are recommended only for people interested in programming and higher mathematics.

Another model of programmable calculator combining the flexibility of programming with simplicity of use is the module programmable calculator. These calculators have specialized navigation programs that can be physically inserted. Even without computer training, the user can spin winds, compute ETAs, compute DRs, do celestial precomps, and many other navigation jobs that can be done manually. These are still programmable calculators, but require no programming on the part of the user.

There is a third type of calculator that is simpler than the two already described. This one is designed specifically for navigation. It accomplishes the same tasks as the other two, but nothing more. It is a specialized computer that requires the user to enter specified information into labeled keys on the calculator face. For example, there is a key labeled TAS for true airspeed entry, a wind direction key, a wind velocity key, a GHA key, etc. Enter the required information and instantly get the answer. For those who want a navigation calculator for no other use, this is the best one. In all three cases, however, the calculators require no inputs different from the MB-4. And further, there is no need to make pencil marks, turn the wheel or

remember right is minus, left is plus, or east is least.

"THE CALCULATOR CAN MALFUNCTION AND CAUSE UNDETECTABLE ERRORS"

I have been using a calculator for three years, and in all that time I have never experienced insidious errors. That is not to say that my calculator hasn't done some strange things on occasion. I've seen weird symbols flash on the display when a malfunction occurred, but in every instance, there was no question that something was wrong. When a hardware or mechanical malfunction occurs the user is warned that something is wrong by either a flashing display or absurdly inaccurate numbers having no place in the results. In other words, malfunctions are immediately obvious. There are no gremlins to worry about. The errors that can cause problems are those induced by the operator.

Given the correct data, the computer, large or small, will solve a problem quickly and efficiently. Enter the wrong data and it will just as quickly and efficiently produce the wrong number—"Garbage in--garbage out." When using a calculator you must be sure that accurate raw data is entered correctly.

Using even the simplest of the three types of calculators the operator must understand how the data is entered and in what form. For example, a celestial calculator must have latitude, longitude, GHA and Dec. This is the same information required for a manual precomp, and the same basic rules apply. Just as east and west longitude have different signs with a manual precomp, the calculator must be told the correct sign of the longitude to compute an accurate Hc. Some operators I have known did not think this was important—they were surprised and disappointed by the results. There is no magic as to how the calculator gets the answer. The results of celestial mechanics and navigation apply with or without a calculator. This type of error, by the way, is not unique to computers, and is definitely not caused by gremlins.

"WHAT WILL HAPPEN TO THE CALCULATOR NAVIGATOR WHEN THE CALCULATOR FAILS?"

This is the only question that has a qualified answer: it depends on the user. The calculator is not a substitute for experience and knowledge. A qualified navigator knows enough about navigation to do the job with or without a calculator. There is no difference between manual and calculator navigation. For celestial, the calculator replaces the HO 249. For DR, it replaces the MB-4. The results obtained from each are the same. An Hc and Zn are going to be used by the navigator in the same way no matter how they are computed. A DR is a DR, is a DR...Basic navigation requires interpretation and judgment on the part of the navigator. When the calculator is no longer useable, this part of the job is not going to change. The navigator will merely acquire the same information from other sources, i.e., the MB-4 and HO 249. The navigator then applies the information the same way.

"WHAT'S THE ADVANTAGE OF USING A CALCULATOR?"

If there's no difference between the information obtained with a calculator or without one, then why use a calculator in the first place? The main reason is that the calculator is faster. Using the calculator, the navigator can accomplish in-flight tasks in one-third of the time.

By saving time on the busywork, the navigator has more time to make judgments about results. By accomplishing more in less time, and with less pressure, the navigator is more efficient. That's really what the calculator is all about—efficiency.

Editor's Note: This article expresses the author's viewpoint: it should not be construed as reflecting Air Force policy or the opinion of THE NAVIGATOR magazine. But, as the author notes, calculators have become extremely popular because they seem to save busywork while providing time to judge results. We applaud any practice with that result.

After graduating from Idaho State University in 1969, Capt Savaglio received his commission through OTS. He graduated from UNT in 1970 and was assigned to the EB-66 at Korat AB, Thailand. Following assignment to Mather AFB as a UNT instructor, he flew the RC-135 with the 24 Strat Recon Sq, Eielson AFB. Capt Savaglio now is assigned to the Computer Center, Offutt AFB.

COMPUTER FLIGHT PL

Captain John D. MCDERMOTT
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INTRODUCTORY NOTE: This article shows the potential of computer flight plans in the day-to-day management of aircrew and aircraft resources. If you are flying the newest, or even the oldest airplane in the inventory, this modern day computer product can be the "razor's edge" in more efficient management.

The Computer Flight Plan (CFP) provides all of the various flying times that are absolutely necessary in coordinating air refueling times, on station/on orbit times, total flying time, and flying time to alternates, if required.

As a mission is set up, a computer flight plan can be ordered from the Air Global Weather Central, Offutt AFB, Nebraska. Even with a mission planned six months in advance, a CFP with mean climatic winds will be available. The data elements available in Global's computer are extensive enough to satisfy any customer.

Computer flight plans are nothing new. They have been around for many years and are used extensively by several MAJCOMs as well as civilian airlines. They are used because of the tremendous advantage computers have in "crunching" large volumes of numbers to provide the kind of data needed by flight crews and staff agencies.

WING LEVEL RESOURCE MANAGEMENT AND THE COMPUTER FLIGHT PLAN

The first key advantage to management is that the CFP can provide long range planning data for scheduling. Having this information far in advance of the mission is a great asset in coordinating aircraft availability with maintenance. It also assists in scheduling SAC tankers and other E-3A mission support tasking that require the assistance of other Air Force agencies.

FUEL MANAGEMENT AND THE COMPUTER FLIGHT PLAN

One of our most pressing considerations is the shortage of fossil fuels. As fuel reserves are reduced, prices increase. Air Force requirements vie for the diminishing quantity of fuel while tight budgets and competing defense priorities compound our problem.

Computer flight plans won't make the energy crisis go away. But they can increase our efficiency in using the available fuel. This efficiency can be translated into more dollars to spend on more tangible (and lasting) Air Force assets.

Efficient fuel use is of top priority in our operational decisions, but there are other important, sometimes conflicting, factors that compete for our attention. Operations supervisors don't want valuable training missions cut short because of miscalculations on the amount of fuel required. They reason that it would be a false economy to curtail a mission because an aircraft had to return to home base early, when we can easily plan for unexpected contingencies by adding more fuel.

The challenge is to balance mission requirements with the growing necessity to be more efficient in the use of our resources. You might ask if these two goals really are compatible. They are compatible—if you have a method to quantify mission objectives. Once you have the numbers, you can use simple probability theory and arrive at a cost for making certain decisions. To clarify, consider this example:

You are a flight manager, and you are planning a round-robin flight of 9½ hours, with an enroute air refueling. You don't want your receiver to shorten the mission in case of a missed air refueling, so you load enough gas to complete the mission, tanker or no tanker. What are some of the key elements of this decision and, more importantly, how much does this decision cost?

First, you must do a little research. You determine that over the last year 1% of your aircraft did not meet the tanker. Next, you must consider the lowest probability of mission success that you will accept. If you must have 100% probability that the mission will be flown as advertised, then you must pay the price for obtaining that extra 1% of certainty.

In other words, there is a 99% probability that your receiver will get the gas from the tanker, and 1% probability that it will not. But you are not happy with that 1% so you load on the extra gas. The cost of carrying that extra gas is how much we pay for your decision.

ANS and Fuel Management

In the E-3A, for example, if we flew one mission per week and accepted the fact that 1% of the time our mission may be cut short, annually we would conserve 494,000 pounds of JP-4, worth about $32,760 at 43¢ per gallon. This is a 7.4% reduction in fuel cost.

This may seem like a small amount, but if you apply the same principles to every mission, to every Air Force aircraft, the potential savings are significant. For ease of illustration, this is a very simplified case. However, this is one very real factor that enters the E-3A flight manager's decision equation. Obviously, there are many other factors to consider, and I believe that many of these can be quantified. For example, missions deemed essential to the national defense may require a 100% certainty of completion, at least as far as is humanly possible. Additionally, seasonal weather variations, available alternates (in case of a missed AR) and other factors enter into the equation. This is the challenge in managing these resources today!

For this management to be effective, the guiding philosophy must be fully understood throughout the organization. It isn't enough to say that we must conserve. How much do we conserve, and what probability of successful mission accomplishment can we live with? In the case of E-3A, to get that extra 1%, we would pay a very high price.

If you were a flight manager, would you take a 1% chance that your mission won't make it? Of course not! It is easier to increase the fuel load than to explain that you were flying with reduced fuel loads to save gas and you're sorry the aircraft had to return to base early. Self preservation says fill up the tanks! We have to make some hard decisions about the tradeoff between more efficient flight operations, and the extra expense incurred to achieve that extra certainty.

Calculating fuel needed for mission using forecasted winds, flight checkpoints, estimated time, plus fuel consumed and remaining at checkpoints.

MORE ON FUEL MANAGEMENT

Before you can do a fuel analysis you need a system that can efficiently crunch large volumes of numbers. Of course, you could fill up a large room with navigators and engineers, but there is a much better way.

The computer flight plan is a tool for efficient and effective fuel management. It can consider factors such as long range cruise airspeeds, optimum altitudes, weight vs altitude limitations and climatology winds.

A computer flight plan also accurately determines fuel consumption. With the ability to precisely determine your fuel requirements, you can plan the ramp fuel and air refueling onload required to accomplish the mission. More fuel carries a very expensive penalty, as discussed earlier.

Personnel in the Military Airlift Command and its global weather service believe computer flight plans could reduce fuel consumption as much as 10 percent for some aircraft. ("No False Alarm," Airman Magazine, February 1978). Another interesting statistic is that on a six-hour mission, approximately 20% of the extra fuel is burned just carrying it around. As a general rule, a 1% increase in gross weight increases fuel consumption by 1%.

The benefits don't stop with reduced fuel consumption. Consider these spinoffs and you'll have to agree they are no small potatoes!

a. Reduced takeoff and landing distance—saves brakes and tires.

b. Higher cruise altitude capability reduces fuel consumption.

c. Improved climb performance is an important safety consideration.

d. Lower gross weight takeoffs mean that a high engine thrust takeoff may not always be necessary. Reduced engine thrust takeoffs can increase engine life significantly. The C-141 A

Mechanic makes minor adjustment on E-3A engine

has been using reduced thrust takeoffs for the past several years. Additionally, noise level is reduced.

Flight planners will also have a precise tool to determine, well in advance, the fuel requirements for a given mission. Consequently, orbit times can be shortened, lengthened or changed as necessary. Second refuelings, refueling onloads, etc., can be determined and coordinated in advance to facilitate effective mission planning. With a CFP, this flight and fuel management tool is available.

THE COMPUTER FLIGHT PLAN AND FLIGHT FOLLOWING

A second area of available management is the ability to flight follow every mission. A computer flight plan provides the:

a. Geographical position of every airborne aircraft at any time.

b. Fuel status of each aircraft at any point in the mission.

c. Fuel situation in case of a missed air refueling.

d. Fuel requirements to divert to alternate bases from any point in the flight, i.e., after the orbit, from the air refueling (AR) track in case of a missed AR, from overhead home base, etc.

e. Flying times to anticipate for coordinating changed AR track and "on station times" due to late takeoffs, and maintenance/crew support for returning missions.

COMPUTER FLIGHT PLANS AND THE FLIGHT CREW

The big benefit is that you don't have to spin out a flight plan. This can save you many hours, especially when planning a long flight. If you mission plan the day before your mission, your CFP will have forecast winds. The winds on your CFP are the best forecast winds available. Believe it or not, your local weather man cannot give you a wind forecast as accurate and precise as is on the CFP. The CFP will also consider temperature changes along your route of flight, a variable you are not likely to consider with manually computed flight plans.

If you plan the day before, and there is a significant change in the winds on the day of your flight, you need to re-spin with the most current winds. This is certainly not the best situation because of the limited time from show time to takeoff time. But with a CFP you don't have this problem. Your CFP (transmitted via AUTODIN six hours prior to your takeoff time) has the latest winds available.

OTHER COMPUTER FLIGHT PLAN USES

CFPs can also facilitate both mobility planning and scheduled deployments by providing complete flight planning and fuel data. They can aid coordination between the wing and other agencies participating in deployment exercises, such as SAC tankers and the aerial delivery groups.

SUMMARY

Computer flight plans can provide accurate, long range planning data to wing managers for accurate and precise mission planning and scheduling.

With a series of delicate maneuvers, E-3A Sentry aircraft will refuel in-flight.

Every computer flight plan is programmed to do a complete fuel analysis, allowing for a minimum fuel load required for mission accomplishment. Flying at reduced gross weights can save considerable money and fuel.

A computer flight plan can be used to flight follow every mission to include fuel status at any point in the mission.

Computer flight plans are more accurate than manually computed flight plans because the data base used for wind/temperature information is more precise and accurate. Many manhours are saved, freeing crew members for more productive work.

As you can see, a computer flight plan has many uses. It has tremendous potential for making life easier for all who need flight planning information. Global's computer can crunch up lots of numbers. This service is an available Air Force asset. It would be a shame not to take advantage of an established, reliable, time-proven system and, instead, continue to do things the hard way.

Captain McDermott graduated from the University of Maryland with a degree in Business Administration. After completing UNT in 1969, he was assigned to the C-141A at McGuire AFB, followed by assignment to the C-130E at Ching Chaun Kang, Taiwan. He next served at Charleston AFB in the C-141A as a Stan/Eval navigator. Currently, Capt McDermott is Chief, E-3A Nav Tng Sec, 552 AWCW, Tinker AFB.

WEATHER PENETRATION OR WEATHER AVOIDANCE?
(Continued from page 13)

reflectivity depends on the availability of some quantization of the display. "Iso-echo" contouring on analog displays has been used for this purpose for many years. The new digital displays introduced commercially in 1976 represent a major improvement in quantization, since these displays offer more flexibility in showing the presence of high reflectivity gradients and the locations of reflectivity maxima.

The 3-cm radar has traditionally been designated a "weather avoidance" radar. It serves the valuable function, noted in the first paragraph, of displaying weather information relative to the aircraft position. It also presents the temptation to rely on it exclusively for weather information at flight altitude, and to use it for weather penetration, particularly in congested airspace. Air Force flight crews can obtain weather information, including radar reports, from forecasters on the "pilot-to-metro" radio service. Comparable weather information has only recently become available to civilian aviation, largely as a result of the Southern Airways accident. The FAA aviation weather program and the Air Force pilot-to-metro service can be most effective for flight operation in the vicinity of severe weather if crews in flight can thereby receive quantitative radar information which will aid them in the interpretation of their on-board radar displays. Information such as the locations and intensities of reflectivity maxima, for example, would be particularly useful for estimating the amount of attenuation affecting the airborne radar. The examples presented in this paper illustrate the need for aircrews to obtain additional weather information including data from ground-based weather radars at any time when the on-board radar shows weather echoes near the projected flight path, particularly when weather penetration is contemplated.

The quest for improved devices and techniques for detecting severe storms continues, as the Air Force Geophysics Laboratory, the Air Force Flight Dynamics Laboratory, Air Weather Service, and other agencies develop new radar data processing techniques and investigate lightning detection systems. While improvements can be expected, the era of the perfectly reliable storm detector is not yet at hand. The effective use of available storm detection devices requires a thorough understanding of their capabilities and their limitations.

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Commissioned through ROTC at Harvard University, Capt Metcalf has a doctorate in Meteorology from the University of Chicago. He served on active duty in the Weather Radar Branch, Air Force Cambridge Research Laboratories (now Air Force Geophysics Laboratory). Since leaving active duty, Capt Metcalf has served in the Air Force Reserve. He was assigned to the Air Weather Service before joining the Air Force Office of Scientific Research at the Georgia Institute of Technology, investigating new techniques in meteorological radar.

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